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By courtesy of the *American Museum Journal.*

Clay buttes along the river.

Such regions we searched carefully, climbing up the clay buttes to trace each channel of rivulets in the hope of discovering some skeleton partly brought to view by the action of the water.

By courtesy of the *American Museum Journal.*

A fossil in position (just above the pick.)

Three hundred feet above the river, an *ankylosaurus* skeleton was found. To obtain the skeleton the side of the hill was blasted off through an area thirty feet long and twenty-five feet high.

FOSSIL HUNTING IN CANADA—[See page 82.]

Fossil Hunting by Boat in Canada*

The Red Deer River Rich in Cretaceous Reptiles

By Barnum Brown
Photographs by the Author

"How do you know where to look for fossils?" is a common question. In general it may be answered that the surface of North America has been pretty well explored by government surveys and scientific expeditions and the geologic age of the larger areas determined. Most important in determining the geologic sequence of the earth's strata are the fossil remains of animal and plant life. A grouping of distant species of fossils correlated with stratigraphic characters in the rocks defines all these subdivisions. When a collection of fossils is desired to represent a certain period, exploring parties are sent to these known areas. Sometimes, however, chance information leads up to most important discoveries, such as resulted from the work of the past two seasons in Alberta, Canada.

A visitor to the museum, Mr. J. L. Wagner, while examining our mineral collections, saw the large bones in the reptile hall and remarked to the curator of mineralogy that he had seen many similar bones near his ranch in the Red Deer Cañon of Alberta. In the course of the conversation an invitation was extended to the writer to visit Mr. Wagner's home and prospect the cañon. Accordingly in the fall of 1909 a preliminary trip was made to the locality.

From Didsbury, a little town north of Calgary, the writer drove eastward ninety miles to the Red Deer River through a portion of the newly opened grain belt of Alberta, destined in the near future to produce a large part of the world's bread. Near the railroad the land is mostly under cultivation and comfortable homes and bountiful grain fields testify to the rich nature of the soil. A few miles eastward the brush-land gives way to a level expanse of grass-covered prairie dotted here and there by large and small lakes probably of glacial origin. Mile after mile the road follows section lines, and one is rarely out of sight of the house of some "homesteader." It is through this level farm land that the Red Deer River wends its way flowing through a cañon far below the surface. Near Wagner's ranch the cañon was prospected and so many bones found that it appeared most desirable to do extended searching along the river.

Usually fossils are found in "bad lands," where extensive areas are denuded of grass and the surface eroded into hills and ravines. A camp is located near some spring or stream and collectors ride or walk over miles of these exposures in each direction till the region is thoroughly explored. Quite different are conditions on the Red Deer River. Cutting through the prairie land the river has formed a cañon two to five hundred feet deep and rarely more than a mile wide at the top. In places the walls are nearly perpendicular and the river winds in its narrow valley, touching one side then crossing to the other so that it is impossible to follow up or down its course any great distance.

It was evident that the most feasible way to work these banks was from a boat; consequently in the summer of 1910 our party proceeded to the town of Red Deer, where the Calgary-Edmonton Railroad crosses the river. There a flat boat, twelve by thirty feet in dimension, was constructed on lines similar to a western ferry boat, having a carrying capacity of eight tons with a twenty-two-foot oar at each end to direct its course. The rapid current averaging about four miles per hour precluded any thought of going up stream in a large boat, so it was constructed on lines sufficiently generous to form a living boat as well as to carry the season's collection of fossils.

Supplied with a season's provisions, lumber for boxes, and plaster for incasing bones, we began our fossil cruise down a cañon which once echoed songs of the *Bois brûlé*, for this was at one time the fur territory of the great Hudson Bay Company.

No more interesting or instructive journey has ever been taken by the writer. High up on the plateau, buildings and haystacks proclaim a well-settled country, but habitations are rarely seen from the river, and for miles we floated through picturesque solitude unbroken save by the roar of the rapids.

Especially characteristic of this cañon are the slides where the current setting against the bank has undermined it until a mountain of earth slips into the river, in some cases almost choking its course. A continual sorting thus goes on, the finer material being carried away while the boulders are left as barriers forming slow moving reaches of calm water and stretches of rapids difficult to navigate during low water. In one of these slides we found several small mammal jaws and teeth not known before from Canada, associated with fossil clam shells of Eocene age.

The long midsummer days in latitude 52 degrees gave many working hours, but with frequent stops to prospect the banks we rarely floated more than twenty miles per day. An occasional flock of ducks and geese were disturbed as our boat approached, and bank beaver houses were frequently passed, but few of the animals were seen during the daytime. Tying the boat to a tree at night we would go ashore to camp among the trees, where after-dinner pipes were smoked in the glow of a great camp fire. Only a fossil hunter or a desert traveler can fully appreciate the luxury of abundant wood and running water. In the stillness of the night the underworld was alive, and many little feet rustled the leaves where daylight disclosed no sound. Then the beaver and muskrat swam up to investigate this new intruder, while from the tree tops came the constant query, "Who! Who!"

For seventy miles the country is thickly wooded with pine and poplar, the stately spruce trees silhouetted against the sky adding a charm to the ever changing scene. Nature has also been kind to the treeless regions beyond, for underneath the fertile prairie, veins of good lignite coal of varying thickness are successively cut by the river. In many places these are worked in the river banks during winter. One vein of excellent quality is eighteen feet thick, although usually they are much thinner. The government right has been taken to mine most of this coal outcropping along the river.

Along the upper portion of the stream are banks of Eocene age, from which shells and mammal jaws were secured, but near the town of Content, where the river bends southward, a new series of rocks appeared, and in these our search was rewarded by finding dinosaur bones similar to those seen at Wagner's ranch. Specimens were found in increasing numbers as we continued our journey, and progress down the river was necessarily much slower. Frequently the boat would be tied up a week or more at one camp while we searched the banks, examining the cliffs layer by layer that no fossil might escape observation. With the little dingey the opposite side of the river was reached so that both sides were covered at the same time from one camp. As soon as a mile or more had been prospected or a new specimen secured, the boat was dropped down to a new convenient anchorage. Box after box was added to the collection till scarcely a cubit's space remained unoccupied on board our fossil ark.

Where prairie bad lands are eroded in innumerable buttes and ravines it is always doubtful if one has seen all exposures, so there was peculiar satisfaction in making a thorough search of these river banks knowing that few if any fossils had escaped observation. On account of the heavy rainfall and frequent sliding of banks new fossils are exposed every season so that in a few years these same banks can again be explored profitably. This river will become as classic hunting ground for reptile remains as the Bad Lands of South Dakota are for mammals.

As a result of the Canadian work the museum is enriched by a magnificent collection of Cretaceous fossils, some of which are new to science.

* Reproduced from the *American Museum Journal*.

Principles of Water-Power Development—II.*

An Issue of the Greatest National Importance

By W. J. McGee

Concluded from Supplement No. 1883, page 67.

LEGAL RELATIONS.

21. Most legal relations affecting the uses of the water of the country are prohibitive or restrictive, or otherwise negative in character; comparatively few thus far developed are positive and constructive.

22. Constructive development of the legal relations of water in eastern United States began with Chief Justice Marshall's interpretations of the commerce clause of the Constitution, largely in McCullough v. Maryland (4 Wheaton, 316-437) and more specifically in Gibbons v. Ogden (9 Wheaton, 1-240), which established federal authority over navigable streams and navigation; and the next noteworthy constructive step was taken by Chief Justice Taney when he cut loose from the English definition of navigability, showed that English standards are wholly inapplicable to this country, and established the principle that the question of navigability is one of fact (the Genesee Chief v. Fitzhugh, 12 Howard, 443, *et seq.*, especially 456-7)—a principle ever since recognized in this country, save as laxity in federal administration and zeal in State aggrandization have permitted insidious invasion of navigable and necessary source streams by devices for other uses of the water. The third step in the same line (with which advance practically terminates) was marked by the Supreme Court decision in the Rio Grande case establishing the power of the federal government to protect the source streams on which depend the navigability of the lower waters (United States v. Rio Grande Dam and Irrigation Company, 174 U. S., 690-710)—the oft-quoted Kansas-Colorado case, though conformable, being virtually a nonsuit and of little bearing on principles affecting the general relations of water.

23. The most significant advance in the development of legal relations affecting the primary use of water in this country was made in a decision of the New Jersey Court of Errors and Appeals, subsequently affirmed by the U. S. Supreme Court, that the people of the State collectively have a residuary right in the intrastate waters (Hudson Water Company v. McCarter, 209 U. S., 349-358) a manifestly valid doctrine which requires nothing but application in other States with respect to their intrastate waters, and extension to the concomitant federal authority over interstate waters in their nature as navigable streams or as sources of such streams, to work a great public benefit. A development of the same equitable principle appears in an opinion of the Supreme Court of Maine that the legislature may prescribe such control of private property in woodlands as may be required to protect public interests in the permanent water supply conserved by the forests; while the Oregon water law of 1909 by clear implication and the California water law of 1911 in specific terms declare that the waters of the State belong to the people of the State.[5]

24. During recent years the Congress has enacted various constructive laws conformable with and even extending the principles so established by the United States and State courts. The most conspicuous of these is that providing for the reclamation of arid districts by expending certain proceeds of public land sales in diverting water from its natural channels to irrigate dry tracts, thereby promoting the public welfare (conformably with the "General Welfare" clause of the Constitution) through a virtual extension of the public domain in substantial accord with the principle of the Spanish-Roman law under which other resources are essentially appurtenant to water. A related principle was applied in the creation and maintenance, through administrative and legislative action, of national forests designed not only to protect timber but to conserve the water of source streams; and it was definitely established as a national policy within a year by an act providing for the purchase of lands in the Appalachian and White Mountains for the specific purpose of conserv-

[5] Some State constitutions, as in Colorado, provide that waters within the State belong to the State, thereby setting up a claim to interstate waters bound to eventuate in expensive and fruitless litigation unless the claims are composed by equitable cooperation and sharing of natural and legal rights and duties between the States and the federal government.

ing source waters, primarily and ostensibly to protect navigation in the lower rivers—though it was well understood in the deliberations attending the enactment that incidental effects of even greater public benefit would arise from protection of the streams in their middle courses where they may be used for power development without impairment—indeed with promotion[6]—of navigability below, and from the general conservation of the natural water for all other uses (in fact it would appear that this act was passed in direct response to a popular demand based on manifest equities and recognition of the public good rather than on any narrow construction of common-law or statutes or decisions).

25. Sundry enactments by the congress during recent decades serve to establish what may be considered an inchoate national policy touching the development of water-power on navigable streams whereby, (1) when a franchise is given a private corporation to erect dams, the federal government reserves the right to use without charge so much of the power developed as may be required for specific purposes, a reservation which may be deemed in the nature of consideration (and recently this was extended by making the consideration specific and limiting the term of the franchise); (2) when works are constructed co-operatively between the federal government and prospective power users the government reserves rights of administration and for specific uses, and also limits the tenure of the lease or franchise to a specified period; and (3) when the dam is constructed at federal cost the leasing of power developed thereby is authorized under conventional restrictions as to advertising, etc. The policy so initiated is not only naturally susceptible of extension with growing knowledge concerning physical relations and the increasing value of power attending the natural growth and orderly development of population and industries, but clearly requires such extension in the interest of general welfare.

26. Federal legislation touching river and harbor improvements has commonly been kept well within the principles laid down by Marshall and Taney, has apparently disregarded the vital principle established in the Rio Grande case, and has shown little progress in the development of standards and ideals conformably to the needs of a great and growing country either for improved transportation or for better use of streams; yet a notable advance has arisen in connection with the work of the Mississippi River Commission which, in co-operation with State officials in Mississippi, Louisiana, and perhaps other States, has extended its work from merely perfunctory revetment of banks for improving navigability in the lower Mississippi to design and location of revetments in co-ordination with the State work for protecting adjacent lowlands, and has even aided in levee construction—thereby establishing (1) the principle of co-operation between State and federal agencies, and (2) a recognized duty on the part of the federal government so to control regimen in navigable streams as to protect adjacent lands.

27. Repeated enactments by the federal congress in conformity with the work and reports of the administrative departments seem to have established at least in inchoate form a duty of the federal government to take measures looking to the control of all the waters of the country in the public interest: In the War Department the physics and hydraulics of the Mississippi were investigated with a view to control of the river; in the War Department and later in the Department of Agriculture rainfall was measured with reference to drainage basins and stream floods, while of late floods are gaged and flood warnings are issued for the public benefit; in the Interior Department the hydrographic branch of the Geological Survey is gaging all the streams of the country and determining their regimen (including the amount of sediment in the water) with a view to more complete control, the work being sometimes done in co-operation with States; in the same department the operations of the Reclamation Service in diverting streams for irrigation, generally in co-operation with individuals and States, are carried forward vigorously; in several bureaus of the Department of Agriculture investigations and measurements of water are conducted with respect to irrigation, drainage, soil-plant circulation, destructive erosion, etc.—indeed it may be said that the function of the department in dealing with water and its derivatives—all looking toward increasingly complete control and utilization for the public benefit, while largely in co-operation with individuals and State institutions, the growing knowledge is applied and the control extended from year to year in increasing degree; in the Department of Commerce and Labor the bureau of corporations has made a systematic investigation of navigation with a view to better regulation of both natural and artificial facilities; and in the same department the Census Bureau has reckoned the actual control of water for irrigation. Under the federal legislation and administrative operations, water is not only measured more accurately than in any other country but is steadily passing under control in the public interest, largely through co-operation with individuals and States, yet always in such wise as to exemplify and establish the common interest of all the people in the water of the country. The advance in this direction during the last decade has been especially rapid; and though apparently little noted, it is among the most significant in our entire history with respect to knowledge, use and administration of the natural waters.

28. Especially in connection with municipalities, a usage has arisen with growing necessities which is congruous with current legal practise in detail, although incongruous with the foreign legal notion that water is a mere appurtenance to land: In all leading cities adequate water supply is provided substantially at public cost, and such lands as may be required to accommodate mains and reservoirs or other works are acquired for the purpose by condemnation or otherwise, while in many cities the lands required for catchment areas are either condemned or purchased, or else arbitrarily protected from contamination, all in accord with the principle of the greatest good to the greatest number; in some cities (notably Los Angeles) the income from power developed by the head of the water is, or is to be, applied in liquidating the cost of both waterworks and land; some municipalities (again notably Los Angeles) allot the surplus water to irrigation for the common benefit, while in many towns and cities the surplus is used in sewerage systems sometimes designed to repay costs through useful disposition of the sewage. The several cases mark growing recognition of the fundamental fact that water is the prime necessary of life and the primary resource, and serve to establish, at least in inchoate form, the doctrine that as population grows dense in relation to the quantity of water, land necessarily becomes a mere appurtenance to that fundamental resource on which the lives of the people depend.

29. Under the generally progressive development of legal relations throughout our history, a foundation has been established not only in equity but in law for constructive action by State and federal legislatures, and for judicial decisions more in accord with current knowledge and existing conditions than with archaic standards developed in other countries of different conditions.

30. The essential principle of natural equity on which specific legislation may rest has already found expression, both by statesmen and by powerful associations of citizens including both jurists and publicists, in the incontrovertible proposition—now become axiomatic—that *all the water belongs to all the people.*

PROPOSED APPLICATION OF PRINCIPLES.

31. Any action looking toward better utilization and development of the water of the country must be influenced by the magnitude of the values involved. Since water is the sole source of productivity and habitability, it is the primary basis of all values; and since the property of the country may be appraised at a figure approaching $150,000,000,000, while the water reserve (stored chiefly in the ground) may be estimated at ten years' rainfall or 50,000,000,000 acre-feet, the one may be balanced against the other as the gold reserve is balanced against the currency whose circulation maintains property values. Reckoned in this way the value of the water reserve may be put at $150,000,000,000 in gross, i. e., $3 per acre-foot or 2.2 mills per ton—a reasonable figure, corresponding fairly with the current cost of irrigation water, and far less than any current water rates in cities or even the ordinary margin of rates above the cost of waterworks. In connection with the gross valuation, it may be noted (chiefly on the basis of estimates by the National Conservation Commission toward the end of 1908) that more than 10,000,000 of our people are supplied—largely from protected catchment areas of over 1,000,000 acres—by waterworks, which for 42 cities (not including Chicago, Philadelphia, Cleveland, Cincinnati, *et. al.*) cost no less than $271,159,483 and perhaps as much more for catchment basins, and supply 1,324,300 acre-feet of domestic water,[7] worth in round figures computed at $3 per acre-foot $4,000,000 annually; that some $200,000,000 are invested in irrigation works, using 34,000,000 acre-feet of water annually to render productive 13,000,000 acres of arid lands; that the water-power available at a cost comparable with that of steam installation is 37,500,000 horse-power (enough to "operate every mill, drive every spindle, propel every train and boat, and light every city, town and village in the country"[8]) worth in gross earning power $20 per horse-power-year or $750,000,000 annually; that the annual loss through draining away of the ground water in only nine interior States, reckoned at $3 per acre-foot, is $442,000,000; that the estimated yearly loss through soil erosion is $500,000,000; that if navigation were so developed that one-fifth of our freight moved by water the annual saving to producers and consumers would be $250,000,000; and that needed drainage of our 75,000,000 acres of swamp and overflow land would add over $20 per acre above the cost of draining (or $1,500,000,000) to our national wealth and provide home-sites for 5,000,000 to 7,500,000 families. Even the most conservative figures indicate that the development, control and utilization of water raises the largest and one of the most pressing economic issues now before the American people.

32. Since the uses of water are interdependent and most of the physical relations interstate, complete control may not be exercised justly either by any single State sovereignty or by exclusive federal sovereignty; so that concurrent legislative and administrative action is required by States and the municipalities within them and by the federal government.

33. Since under the Constitution the federal government is primarily responsible for the general welfare, requisite action may properly, and in view of the urgent demand should without needless delay, be initiated by the congress.

34. The magnitude and complexity of the interests affected, the delicacy of the legal relations involved, and the dearth of both exact knowledge and practical experience concerning the several uses of water, all indicate that action taken at this juncture should be constructive and developmental rather than definitive. While the relations in equity seem clear, and while the legal relations appear to form a firm foundation for a broader legal structure than has hitherto been attempted, the technical experience needed to guide definitive legislation remains inadequate: It is barely over a decade since electric power transmission began reconstructing industries, since the internal-combustion engine began closing the age of steam (which may reopen under the steam-turbine) since steel-concrete construction began revolutionizing the use of resources, since irrigation began opening a new era in standards of production; and the concepts of even the most advanced jurists and law-makers can hardly be quite abreast with, much less far in advance of, the technical experience attending these industrial developments. Moreover, the concept of water as a common possession in equity of all the people remains novel in many minds, and is bound to result in new and unforseeable interrelations among individuals and civic organizations, and especially between States and the federal government—interrelations that can be adjusted and regulated in the common welfare only as common experience grows with advancing applications of increasing knowledge. It would no more be practicable to establish definitive regulations for the use of the natural waters to-day than it would have been to create our magnificent railway system by fiat 80 years ago, to establish our intricate banking system when the Constitution was framed, or to found by a stroke of the pen 20 years ago the Department of Agriculture with its hundreds of scientific experts, made such by long-continued training. The need for action presses; but wise action to-day can be no more than preparatory for, and directive of, prospective and inevitable development.

35. Since practical experience is a *sine qua non* for wise legislation, early State and federal enactments should be framed in general terms, entrusting the actual work to administrative agencies under proper restrictions and provisions for reporting progress to the legislative authority, much as in the statutory authority for State and federal departments.

37. While the magnitude and importance of the issue involved in control and utilization of water would warrant the creation of a federal department to meet it, such action at this juncture might be premature—especially since the more pressing requirements may be met through existing departmental facilities. The several considerations point toward a presumptively temporary federal administrative agency, created or empowered to make investigations and take action looking toward the progressive control and regulation of the water of the country with respect to all uses, both directly and in co-operation with States and when needful with individuals, corporations, communities and municipalities—such agency to report through the executive annually and at such other times and in such modes as the congress may require. It should be among the first duties of the federal agency to confer with officers or other competent representatives of States concerning water-power and other uses of water with a view to determining means of effective co-operation, equitable sharing of rights and responsibilities, estimates of cost of works required for State and federal use, reasonable rates for domestic and irrigation water supply and for power, and all other matters of common concern to the State and federal governments—the determinations to be reported to the State legislatures and to the congress as a basis for further action in the public interest in accordance with the righteous principles of the greatest good to the greatest number for the longest time.

[6] Not only does each open reservoir for power development hold back the flow of the stream and so shorten the low-water season, but each serves to saturate the adjacent soil and subsoil and rock with an additional volume of water subserving the same end—a volume often comparable with that of the pond itself.

[7] Report of the National Conservation Commission (60th Congress, 2d Session, Senate Document 676), 1909, vol. ii., p. 178.

[8] *Ibid.*, vol. i., p. 41.

Photographic Tests of Automatic Gun Locks

Fine Work in Accurate Measurement of Minute Time Intervals

THE newest types of small arms resemble machine guns in that the spent cartridge shells are ejected and fresh cartridges introduced automatically by means of a specially contrived lock, the required energy being furnished directly or indirectly by the compressed gases of the preceding shot. It is necessary for the safety of the rifleman that the breech shall remain tightly closed so long as any considerable pressure remains in the barrel. Furthermore, the initial velocity of the projectile might be diminished if a second way of escape existed for the gases before the projectile had attained its maximum velocity. Hence it is very desirable to determine how far the lock has moved while the projectile has traversed a given distance and to ascertain whether the movements of the lock are regular and uniform, or vary in different shots.

An excellent and probably the only available method of recording the very rapid movements of automatic locks is furnished by spark photography. In this truly instantaneous method of photography the illumination, and therefore the exposure, is only about one-millionth of a second, yet it can be measured with a fair degree of accuracy. If a camera is so focused upon a motionless projectile that the size of the photograph is exactly equal to that of the projectile and if the same projectile is photographed in flight by Dr. Mach's method, it is found that a velocity of 900 meters (about 3,000 feet) per second elongates the image by about one millimeter. This shows that the duration of the spark is equal to the time required by the projectile to move one millimeter, or about one-millionth of a second.

Fig. 1.—Silhouette of Lock With Spark Gaps Marked I and II.

Fig. 2.—Four Shots, With Interrupter Placed 0. 1, 2, 3 Meters in Front of Muzzle.

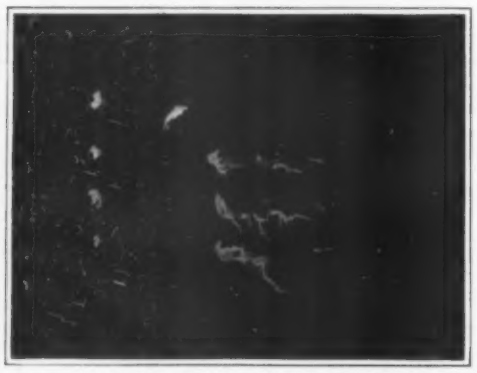


Fig. 3.—Three Shots With Interrupter Placed at Muzzle.

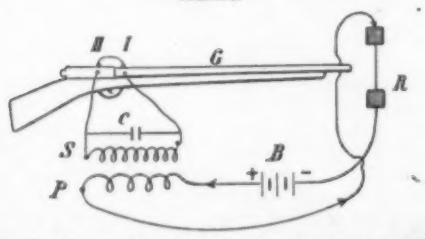


Fig. 7.—Connections of Induction Coil With Rifle.

Spark photography has often been used for testing automatic gun locks, usually, if not always, by producing silhouette photographs of a lock by means of sparks from a static electrical machine. This method requires that some conspicuous part of the lock shall move in such a manner that the movements of the other essential parts can be inferred with certainty from the change in the silhouette. This condition is not satisfied by all automatic locks. Furthermore, the satisfactory employment of the static electrical machine is largely dependent upon the weather.

Dr. Friedrick Waechter of the Austrian military service, therefore, sought a more expeditious and convenient method, independent of the momentary external form of the lock. This last condition is not easily satisfied, as the rapidly moving lock cannot be photographed in the millionth of a second by the reflected light of the spark, so as to show all of its parts. Dr. Waechter, whose article in *Mitteilungen neber Gegenstaede des Artillerie und Geniewesens* is here summarized, decided to produce the sparks at definite places in the lock and to photograph the sparks rather than the lock itself. Fig. 1 shows a silhouette photograph of a lock in which I and II denote the spark gaps. The photograph was taken immediately before the shot when the hammer touched the cap and the distance between the spark gaps was 43 millimeters.

If the sparks are produced by the projectiles cutting a wire placed immediately before the muzzle or at a distance of one, two, three meters, the distance between the two spark gaps gradually increases (Fig. 2) until the lock has opened to its maximum extent. The spark gap I occupies a fixed position relatively to the gun barrel, while the spark gap II is placed in a part which moves in a manner characteristic of the operation of the automatic lock. The sparks photographed in Fig. 2 were produced by an influence machine, which can be used without difficulty in the laboratory. On the firing ground it was found quite impossible to produce sufficient electrical tension and to secure satisfactory insulation with the influence machine, which was therefore replaced by an induction coil. This substitution makes it necessary to allow for the appreciable interval of time between the interruption of the primary circuit and the production of the spark in the secondary circuit. This interval was determined to be 0.0025 second with a current of about 15 amperes.

In one series of experiments an automatic rifle made by Roth of Vienna was tested. The initial velocity of the bullet was about 900 meters. It was found necessary to pull back the trigger 28 millimeters before the breech began to open, 42 millimeters before it was quite free and 117 millimeters before it attained its greatest distance. The distance between the two spark gaps was 43 millimeters, when the lock was closed.

In the first experiment three shots were fired with the interrupting device placed close to the muzzle, so that the primary circuit was broken at the moment the bullet left the gun. As the retardation of the spark was 0.0025 second and the velocity of the bullet was 900 meters, the bullet was 2.25 meters away from the muzzle when it was photographed. In each of these three photographs the distance between the spark gaps corresponded to a real distance of 57.3 millimeters. Hence the trigger had moved 57.3 — 43 = 14.3 millimeters backward from the cap; but the breech was still tightly closed, as it did not begin to open until the trigger had moved 28 millimeters.

In the second experiment the circuit was interrupted, by a device attached to the lock, at the moment when the hammer struck the cap. The interval of 0.0025 second sufficed for the ignition of the powder and for some motion of the projectile. If we assume the mean velocity of the bullet inside the barrel to be 550 meters per second, it required 0.001 second to traverse the length of the barrel, 670 millimeters. The interval between the ignition of the powder and the first movement of the bullet cannot be measured, but is very small. Hence, the time available for movement outside the barrel before the photograph is taken, was 0.0025 — 0.0012 = 0.0013 second, which corresponds to a distance of 900 millimeters; if 0.0003 second is allowed for ignition (not combustion) of the powder. The result is illustrated in Fig. 4 which clearly shows the broken wire of the primary circuit between the two sparks. The distance between the sparks is 49.1 millimeters, hence the lock had moved 49.1 — 43 = 6.1 millimeters backward at the moment when the bullet was 900 millimeters in front of the muzzle.

In two other experiments, the results of which are shown in Figs. 5 and 6, the interrupter was placed successively at distances of 1.6, 2.6, 3.6 and 4.6 meters in front of the muzzle. Each of these distances must, of course, be increased by 2.25 meters, owing to the retardation of the spark. From curves plotted from these experiments it appears that the bullet was 0.2 meters in front of the muzzle when the lock began to move, 3.2 meters when the lock began to open, and 4.35 when it was completely open.

An automatic rifle and a pistol of the Steyr Company were also tested with the following results:

Movement of the Lock.	Distance of bullet from muzzle.	
	Pistol. (Meters.)	Rifle (Meters.)
Beginning of movement...	0.95	3.00
Lock free.....	1.30	5.40
Lock fully open.....	3.40	22.40
Lock closed.....	10.50	.....

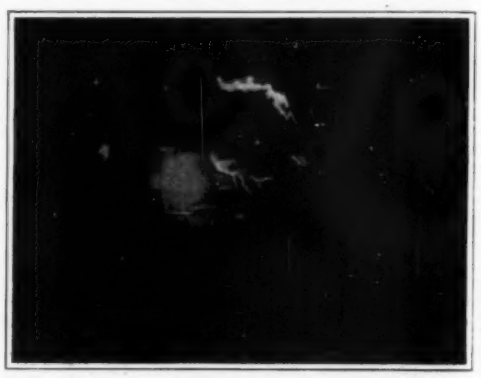


Fig. 4.—Shot With Interrupter at Muzzle (Above). Shot With Circuit Broken by Lock (Below).

Fig. 5.—Three Shots With Interrupter at Various Distances (Above, Position of Sparks With Lock Closed and Wide Open).

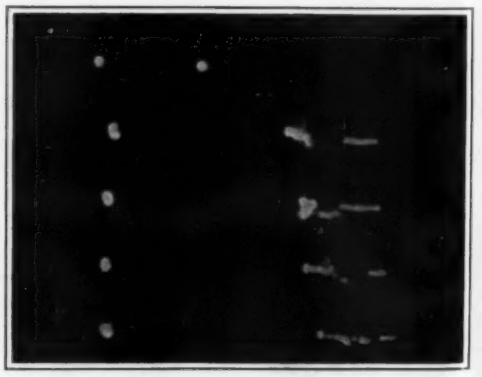


Fig. 6.—Four Shots With Interrupter at Various Distances.

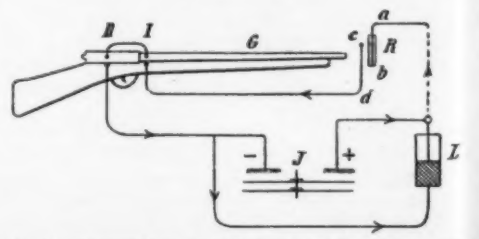


Fig. 8.—Connections of Influence Machine With Rifle.

These results show that the lock is not open until the projectile is well on its way. The movements of the lock were remarkably uniform and constant, in the different experiments.

The arrangement of apparatus is shown by the diagram Fig. 7, in which *B* denotes the galvanic battery, *P* the primary coil and *R* the wire which is broken by the bullet. The secondary coil *S* is connected with the condenser *C* and discharges through the spark gaps *I* and *II*, attached to the rifle *G*. The spark gap *I* is attached to the stock or the barrel; the spark gap *II* to a moving part of the lock. It is advisable, though not absolutely necessary, to insulate the gun from the ground. The trigger should be pulled by means of a cord or insulated hook in order to prevent the operator suffering a shock. The interrupter screen should be composed of steel wires of about 1.2 millimeters diameter, which have been quenched at a white heat in cold water, making them so brittle that they break at a touch of the finger. If the thin, soft copper wires usually employed for such purposes are used, the pointed projectiles may slip between them without breaking them, or the wires may be stretched before breaking and the broken ends may make multiple contacts with unbroken wires, producing a shower of sparks and a very complicated image. The camera is so placed that the whole lock at its widest extension can be focused sharply on the plate. It is desirable to inclose the rifle and the camera in a light, tight box or other envelope, inside of which almost absolute darkness can be maintained.

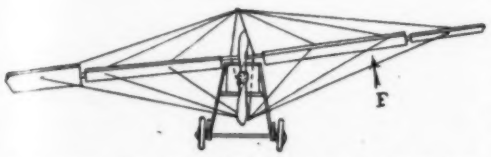
When a static electrical machine is employed, the apparatus is arranged as shown in Fig. 8, in which *J* denotes the electrical machine, *L* a Leyden jar, *R* the contact screen with its wires *ab* and *cd*, and *G* the rifle with its two spark gaps, *I* and *II*. The wire *ab* must be insulated by placing it in a glass tube. When the bullet breaks this tube and passes between the wires, the sparks are produced. This arrangement has the great advantage of allowing no appreciable time to intervene between the discharge and the production of the spark. The position of the contact screen therefore indicates the point occupied by the projectile at the moment when it is photographed, while with an induction coil an allowance must be made for retardation of the spark. The coil, however, operates unfailingly in any condition of weather, while the influence machine is not sufficiently powerful to withstand the great losses from the long wires except in very dry weather. Furthermore, the contact produced by the projectile is not reliable, so that even when the electrification is sufficient only every fourth or fifth shot gives a satisfactory result.

A New Automatic Aeroplane Stabilizer

Auxiliary Ailerons Controlled by the Motion of the Main Wings

By Our Paris Correspondent

Our illustrations show a new aeroplane stabilizer recently tested at the Port Aviation grounds near Paris. The aeroplane was piloted by Sotinel and gave every satisfaction, both in straight flight and in rounding curves, ascending or descending. The inventors, Messrs. Guerin and Corneloup, spent two years in perfecting their apparatus, which was recently exhibited at the



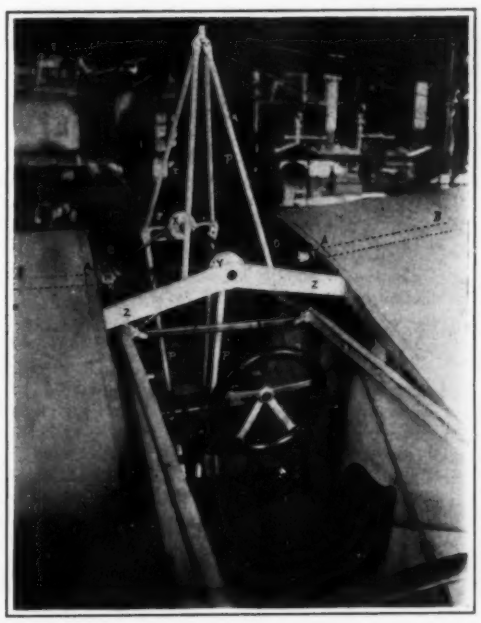
Front View. The Lateral Oscillation of the Wings Produced by Any Excess of Pressure *F* Causes the Rotation of the Terminal Ailerons.

1911 aeroplane show at Paris. The special feature of this stabilizer, which distinguishes it from other devices of this class proposed hitherto, is that it forms part of the aeroplane itself, and therefore does not represent so much additional weight to be carried on board.

The machine illustrated here is a monoplane of the model type, to which the new system is applied by modifying certain parts. The two wings are made to pivot about a central axis *X Y*, each wing being attached to a rigid bar *Z*. The wings are sustained by brace wires attached to a system of rods *P*. At the tip of each of the main wings is a small auxiliary wing which works independently, and is mounted on a tube running through the main wing. One end of the tube is pivoted in the inner end of the main wing at *A*, and the outer end is held in a bearing at the tip of the main wing, ball bearings being used in each case. At its inner end the tube *A B* bears a crank lever *M*, the other extremity *O*, of which is pivotally connected to a bracket *N* rigidly attached to the frame of the aeroplane. Thus the auxiliary wings receive a certain definite motion with each movement of the main wings, the arrangement being such, that the auxiliary wing on the riding side presents now a smaller angle to the wind, while that on the opposite side is turned more fully across the wind. The aeroplane body itself adjusts its position like a pendulum. When the course is straight, the body hangs vertical; when rounding a curve, it takes up a position determined by the resultant of gravity and centrifugal force. Wind blasts and other adventitious disturbances merely act on the wings, causing them to pivot slightly about their axis, and this movement instantly causes the stabilizing response of the auxiliary wings. The inventor claims that this arrangement not only automatically performs the work which would otherwise fall to the pilot, but that a stronger effect is obtained than could be secured merely by hand working, with say the 60 or 70-pound pull available. For, he argues, the entire weight of the aeroplane body and motor control the motion of the stabilizing winglets. Moreover, the requisite motion is produced instantly as soon as the occasion calls for it.

The aeroplane itself requires but little modification from the usual types. Thus, there is no extra weight added, as in the case of such devices as the Doutre stabilizer, for example. There are no fragile parts to give way at the critical moment. The aviator is relieved of a material part of his maneuvers, and merely has to attend to the vertical and lateral rudders. It is claimed that the Guerin-Corneloup aeroplane can fly in far worse weather than the usual types of machines, and that the security of the pilot is greatly increased, especially in the case of beginners. M. Sotinel tells us that he was able to make much sharper turns with his machine at the trial flights at Port Aviation than with other machines.

General View of the Guerin-Corneloup Aeroplane With Stabilizing Ailerons.



View Showing the Mechanism by Which the Motion of the Wings Causes a Compensating Rotation of the Ailerons.

The Rhone Water Power at Paris

THE inhabitants of the French capital have set about exploiting the Lake of Geneva in two different ways. On the one hand, they have long thought of conveying its clear mountain water through a mammoth aqueduct as far as Paris, for use there in place of the rather objectionable Seine water. On the other hand, they have been planning to utilize the water power of the upper Rhône at its outflow from the lake, and this plan is now to be carried into practice.

It is intended to build a huge embankment at Génissiat, which is to convert the whole valley of the upper Rhône as far as Geneva, into an artificial lake 23 kilometers in length and 50,000,000 cubic meters in capacity. The head of 67 to 69 meters thus available would supply up to 246,500 kilowatts, while the number of kilowatt-hours available during a year (1¼ thousand millions) would be equivalent to the energy supplied by the combustion of 1,500,000 tons of coal.

So far from having any reason for complaint, the citizens of Geneva will derive from this scheme a most material advantage, the difficult problem of navigation of the upper Rhône being solved by the sluice system contemplated, which will effectively control the water level. Elevators will be installed on which the vessels are to overcome any differences of level. While raising many difficult engineering problems, the construction of this gigantic embankment would seem to be feasible.

The power-house to be installed at the foot of the embankment is designed for a total output of 240,000 kilowatts, to be distributed over 25 units of 10,000 kilowatts and 16 units of 15,000 kilowatts each. In view of the increasing use of high tension even in European power plants, the three-phase current tension of 120,000 volts (possibly 150,000 volts) to be adopted for transmission would not seem to be unusual. The three-phase current supplied by the power-house at a tension of 12,000 volts is to be transformed into high tension in a transformer house about 800 feet long.

The Francis turbines mounted in pairs on the same axis are to work at a speed of 250 revolutions per minute, driving 12-pole three-phase generators of 10,000 (or 15,000) kilowatts each. The continuous-current exciter machines (750 kilowatts, 160 volts) are to be operated by vertical turbines. Each turbo-generator set is to be quite self-contained. Any orders relating to the operation of the power-house are to be given out by remote control, the staff of the power-house being free to interrupt but not to re-establish the current.

In addition to the 112,000-volt current supply for the city of Paris, current at 30,000 volts is to be supplied to the neighboring departments and current at 12,000 volts to the local electro-chemical works.

The four high-tension transmission lines from Génissiat to Paris are to convey no less than 80,000 to 100,000 kilowatts. They are to be divided into two groups following different paths, each line to be subdivided by section switches into sections of 100 kilometers each; transversal lines will enable any injured section to be cut out without interfering with the operation of the plant. Radiation losses will be reduced by the use of 8-inch aluminium wires arranged 10 feet apart and carried by steel towers 65 feet in height.

A Cup of Tea

Its Chemistry, Physiology and Æsthetics

A VERY interesting article on the chemistry and physiology of tea appears in a recent issue of the *Lancet*, an extract of the main facts of which is given here.

When an infusion of tea (which always exhibits an alkaline reaction) is acidified, a flaky buff-colored precipitate settles out, especially in the cold. This precipitate is found to consist chiefly of caffeine tannate; it contains caffeine and tannin in the proportion of one to three, and presumably consists of one molecule of caffeine $C_8\ H_{10}\ N_4\ O_2$, with a molecular weight of 194, associated with one molecule of quercitannic acid $C_{76}\ H_{52}\ O_{46}$, with a molecular weight of 602.

The ratio of caffeine and tannin in such a compound would be 1:3.1. The following is an example of the analysis of this precipitate for a good Indian tea:

Caffeine	20.93 per cent.
Tannin	62.80 " "
Resinous and oily matters (by difference)	16.27 " "
Total	100.00 " "

The precipitate amounted to 9.84 per cent of the tea used in the infusion. A further experiment gave the following results:

Caffeine	20.89 per cent.
Tannin	62.66 " "
Resinous and oily matters (by difference)	16.45 " "
Total	100.00 " "

It follows that the precipitate obtained on making an infusion of tea acid consists principally of caffeine and tannin in the ratio approximately of 1 of the former to 3 of the latter. The presumption is that caffeine tannate is the chief body thrown out of solution by the addition of acid.

When, however, this precipitate is removed by filtration and the filtrate is saturated with ammonium sulphate a further separation of buff-colored flakes takes place. On analysis these flakes show the following composition:

Caffeine	24.13 per cent.
Tannin	75.80 " "

$$\frac{\text{Tannin}}{\text{Caffeine}} = 3.14$$

The ammonium sulphate precipitate amounted to 4 per cent of the tea used in the infusion (5 grammes in 400 cubic centimeters of just boiling water allowed to stand five minutes before pouring off). Calculation shows that this particular tea yielded a total of caffeine tannate of 12.26 per cent. Of this total 8.26 was thrown out by mere addition of acid and 4 per cent by subsequent saturation of the filtered acid infusion with ammonium sulphate. There is no point in separating caffeine tannate first by acidifying and next by saturating with ammonium sulphate. The whole can be thrown down at once by adding ammonium sulphate after acidifying the tea infusion with dilute sulphuric acid. When this precipitate is air dried and sunk in a mixture of 1 of alcohol and 2 of benzene the caffeine tannate is separated from the excess of ammonium sulphate crystals and resins and obtained in a comparatively pure state. The solution of caffeine tannate in benzene-alcohol mixture readily yields its tannin to lead oxide (litharge), the caffeine being set free. To give an example, a certain tea (Indian) yielded a total precipitate by ammonium sulphate amounting to 11.60 per cent when dissolved in benzene-alcohol mixture and evaporated to dryness and weighed. The following was the process. A definite volume of the alcohol-benzene solution of the caffeine tannate was evaporated over a weighed quantity of lead oxide. The dry residue was then made into a thick paste with water and extracted with chloroform, which was poured off and evaporated in a platinum basin. The residue from the chloroform represents the caffeine contained in the caffeine tannate. The wet lead oxide paste was then dried to constant weight and the increase of weight shown over the original amount of lead oxide weighed out was regarded to be due to tannin. In this way a residue of 11.60 per cent obtained by evaporating the alcohol-benzene mixture to dryness gave on treatment in the way just described:

Caffeine	2.80 per cent.
Tannin	8.80 " "
Total (caffeine tannate)	11.60 " "

With another tea the total caffeine tannate extracted from the ammonium sulphate precipitate by benzene-alcohol mixture was 12.80 per cent, and the constituents found by lead oxide separation were:

Caffeine	3.20 per cent.
Tannin	9.60 " "
Total (caffeine tannate)	12.80 " "

These experiments thus appear, to establish that, complex as the composition of an infusion of tea may be, it at least yields a definite substance in the shape of caffeine tannate, the composition of which is constantly shown to be one part of caffeine with three parts of tannin.

THE PREPARATION AND COMPOSITION OF CAFFEINE TANNATE.

Caffeine tannate is a very interesting substance apart from its occurrence in tea infusion. It may readily be prepared by mixing aqueous solutions respectively of tannin and caffeine in the cold, when a milky fluid, sometimes with flakes forming according to the strengths of the solutions, is obtained. If a few drops of carbonate of soda solution be added to the mixture a clear pale yellow solution results. If next a slight excess of dilute sulphuric acid be added caffeine tannate separates in flakes which admit of washing to remove free caffeine or tannin as the case may be. These flakes may be dissolved in alcohol-benzene mixture (1 to 2). On evaporating the solution to dryness a crisp crust of caffeine tannate is obtained. If this residue is taken up again in benzene-alcohol and evaporated over a weighed quantity of lead oxide the two constituents are separated. On evaporating the benzene-alcohol and moistening the mass with water to a paste, chloroform may be added which will extract the whole of the caffeine; the lead residue on drying to constant weight will give the amount of tannin as an increased weight on the lead oxide employed. To give an illustration. A benzene-alcohol solution of the precipitate obtained by adding acid to a solution of caffeine and tannin in weak carbonate of soda was evaporated to dryness. The weight was 0.1 gramme. The residue was redissolved in benzene-alcohol and the solution so obtained was evaporated to dryness in a platinum basin containing 3.210 grammes of lead oxide (litharge). The dried mass, after moistening, was extracted with cholroform. The residue (caffeine) from the chloroform, clean and white, weighed 0.025 gramme. The lead oxide, after being exhausted with chloroform, was then dried at 120 deg. Cent., to constant weight. The weight proved to be 3.287 grammes, which represents a gain due to tannin of 3.287—3.210, or 0.077 gramme. The 0.100 gramme of caffeine tannate was thus split into 0.025 gramme of caffeine and 0.77 of tannin, figures which account for the whole of the original substance taken, and which give the quotient 3.08 when the proportion of tannin is divided by the proportion of caffeine. Caffeine tannate is readily soluble in boiling hot water, but as the solution cools it turns milky. It is, however, permanently soluble in water containing a little alcohol. If caffeine tannate be heated with a little water for some time it assumes the form of an oil.

It was next decided to add an excess of caffeine in solution to a known amount of tannin in solution. If tannin selects a definite amount of caffeine to form a compound it is evident that by estimating the remaining free caffeine in the mixed solution the amount that has combined with the tannin can be ascertained. Thus, 0.3 gramme of caffeine in solution was added to 0.3 gramme of tannin in solution, a few drops of carbonate of soda solution were added to make the mixture quite clear, and then dilute sulphuric acid was added in slight excess. Caffeine tannate readily separated in flakes from which a clear fluid could easily be poured off. The clear fluid was then repeatedly extracted with chloroform and the chloroform extractions were evaporated. The data and results were as follows:

Caffeine taken	0.3 gramme.
Tannin "	0.3 "
Calculated caffeine in excess, assuming that 1 of caffeine combines with 3 of tannin	0.2 "
Caffeine in excess found	0.189

It is difficult to extract caffeine completely from a bulky aqueous solution, but the result shows an approximation to a combination of 1 of caffeine with 3 of tannin having been formed.

Next the precipitate obtained (caffeine tannate) was split up by lead oxide as previously described:

Caffeine tannate taken weighed	0.284 gramme.
Tannin found	0.214 "
Caffeine "	0.075 "
Total	0.289 "

The evidence is here again strong in favor of the existence of a definite compound of caffeine and tannin, consisting one of the former and three of the latter.

The reverse experiment was next tried—that is, an excess of tannin in solution was added to a known amount of caffeine in solution:

Tannin taken	0.30 gramme.
Caffeine "	0.03 "
Calculated excess of tannin	=0.21 "

The mixed solutions were saturated with ammonium sulphate and thrown upon a filter. The filtrate was exhausted with ethyl acetate and the extraction evaporated to dryness (we noted before that free tannin is soluble in saturated ammonium sulphate, but that caffeine tannate is insoluble). The ethyl acetate gave 0.205 gramme free tannin against 0.21 calculated. The caffeine tannate formed was again split up by means of lead oxide, and there were obtained 0.10 gramme tannin and 0.03 caffeine, a total of 0.13 gramme caffeine tannate formed against a calculated 0.12 gramme.

CAFFEINE TANNATE PHYSIOLOGICALLY CONSIDERED.

We suggest that these findings are important from a physiological point of view, because it is highly probable that caffeine in a state of stable chemical union with tannin must differ very materially in regard to therapeutic action from the alkaloid in a free or uncombined condition, especially having regard to the fact that tannin serves to some extent as an antidote to most alkaloids since it forms with them insoluble compounds. Similarly tannin when combined with caffeine is a totally different thing from tannin in the free state. The astringent properties of tannin, for example, disappear when it is combined definitely with caffeine. It follows that tannin in combination with caffeine will not tan. A solution of pure caffeine tannate does not act upon gelatin or proteins, so that when tannin is combined with caffeine its incompatibility with these dietetic substances ceases, and its objectionable retarding action upon digestion accordingly must be modified. If these conclusions are correct it becomes of the utmost importance to determine whether in the enormously popular beverage tea, caffeine or tannin exists in the free state or mutually combined.

We have already shown that to a large extent the teas which are regarded as of high quality by the merchant prove to yield infusions containing caffeine and tannin in the ratio of 1 to 3, and the strong inference is that such infusions contain neither free tannin nor caffeine, but neutral caffeine tannate. The merchant's view of quality would thus appear to accord quite happily with physiological considerations. He is guided, of course, chiefly by the flavor of the infusion, as well as by color and odor and general appearances. Both tannin and caffeine in the free state have characteristic tastes; the former is astringent and sour, the latter is bitter. A slight excess of caffeine in tea infusion is probably less objectionable than an excess of tannin, since the disagreeable qualities of tannin are more marked. An ideal infusion is one which contains both caffeine and tannin in 1 to 3 proportions, i. e., caffeine tannate, neither constituent being in excess. This ideal is occasionally reached, but, generally speaking, most good teas contain caffeine in slight excess. Caffeine tannate, however, does not possess the qualities of its constituents; it has a peculiar flavor which is smooth and bland, not unlike a very delicate or lightly infused tea. It must be carefully borne in mind that in making these deductions we are not considering the chemistry of the leaf, but of its infusion made by pouring 400 cubic centimeters of just boiled water upon 5 grammes of tea and decanting after 5 minutes—a plan suggested by the tea-taster's method of assaying tea.

THE EFFECT OF "STEWING" SOME TEAS.

The desirable equilibrium may be disturbed by vicious treatment even of a good tea. If an Indian tea be boiled long enough or stewed on the hob a point is reached when tannin appears over and above the amount which can combine with the caffeine to form neutral caffeine tannate. Such an infusion presents the objectionable characters of tannin. When this infusion is saturated with ammonium sulphate the caffeine tannate as such is thrown out. If this is filtered off the excess of tannin will be found in the filtrate, from which it can be extracted by ethyl acetate. Thus the five minutes' infusion of an Indian tea showed a total tannin content of 9.24 per cent and caffeine 3.70 per cent. On infusing the same tea for one hour the tannin amounted to 16.12 per cent and the caffeine 4.40 per cent. In the five minutes' infusion, therefore, caffeine was in slight excess (0.38 per cent) of the tannin, but in the one hour's infusion the tannin is in excess of the caffeine by 2.92 per cent. In other words, 4.40 of caffeine if combined as tannate would mean in the

combination 13.2 of tannin, when as a matter of fact the total tannin found was 16.12 per cent.

The experience of making wholesome tea seems to have decided upon a limited time for making the infusion. This limit, in fact, appears to us to insist upon the infusion consisting as far as possible of caffeine tannate and upon the exclusion of an important quantity of free tannin or caffeine present. But even a five minutes' infusion of some teas may not approach this standard. Indeed, in view of our work upon the subject we are able to suggest a classification for teas as follows:

Good teas are those which on a five minutes' infusion yield only caffeine in the form of caffeine tannate to the infusion, neither caffeine nor tannin being in excess; and bad teas are those which yield on infusion for five minutes a tea containing in addition to caffeine tannate either caffeine or tannin, but especially tannin, in excess.

It is obvious from this classification that a good tea may be made a bad tea, but a bad tea cannot be made a good tea, except possibly by very skilful blending. Excessive infusion will spoil a good tea, but a short infusion of a bad tea may be as objectionable as an excessive infusion of a good tea. On physiological grounds, therefore, the buyer of high-quality teas runs less risk of digestive disturbance provided he makes the tea properly.

These points are interesting in connection with the light types of tea grown in China. The short infusions of these teas commonly contain an excess of caffeine, which probably accounts for their bitterness. They are less rich than Indian teas, a fact which should make the use of Indian teas more economical, but the best types of them never show the presence of free tannin. A five minutes' infusion of a certain China tea showed a total amount of tannin of 4.60 per cent and caffeine 2.80 per cent. On the basis of the 1 to 3 relationship of caffeine to tannin in caffeine tannate it is evident that in this tea there is an excess of caffeine, viz., 1.27 per cent, for the amount of caffeine that can combine with 4.60 of tannin is 1.53, making a total of 6.13 per cent of tannate. As a matter of fact, the amount of caffeine thrown out as tannate when the infusion was saturated with ammonium sulphate was 6.48, which requires 1.62 of caffeine and 4.86 of tannin. In the five minutes' infusion, therefore, there was 1.27 per cent of caffeine in excess. On infusing the same tea for an hour, however, the tannin then amounted to 7.14 per cent and the caffeine to 3.20 per cent. Caffeine is still in excess, for the amount combined as tannate is 2.38 per cent, giving a difference of 3.2—2.38 = 0.82 per cent. Some China teas, therefore, are incapable of yielding free tannin, and these are invariably high-priced teas.

ANALYSES OF INFUSIONS OF VARIOUS TEAS.

In the following table will be found a series of analyses of infusions made with Indian, Ceylon, and China teas, respectively. The percentage results are based upon 5 grammes of tea used in the experiment, to which were added 400 cubic centimeters of just boiling water, the infusion being poured off after five minutes. The qualities of the teas from the merchant's point of view are indicated by the brokers' prices which are attached. It will ge noted that, as a rule, the high-priced teas yield infusions containing a balance of tannin and caffeine, and in general a larger amount of these constituents. The use of a high quality tea is therefore not only salutary but economical also. A very fine example of Indian tea is No. 7. The infusion contained as much as 4 per cent of caffeine and 9.50 per cent of tannin. There was only 0.1 per cent of tannin uncombined with caffeine and 0.90 per cent of caffeine uncombined with tannin. The price of this tea was 45 cents per pound. On the other hand, Indian tea at about half the price—23 cents—gave 8.73 per cent of tannin and 3.20 per cent of caffeine, and there was 1.53 per cent of tannin not combined with caffeine, and the liquor was accordingly harsh and astringent, although the time of infusion was only five minutes. The same applies to the Ceylon teas; a tea quoted at 32 cents per pound yielded no tannin over and above what is combined as tannate, while one tea quoted at 21 cents gave 2.02 tannin in excess. The tea at 32 cents again yielded 3.60 per cent of caffeine, while the tea at 21 cents gave 1.96. Ceylon teas, as a rule, show a more regularly balanced composition as regards the ratio of tannin to caffeine (3 to 1), a finding which would seem to show that Ceylon teas are all that can be asked for from a physiological point of view.

Analyses of Infusions of Various Teas.

Description.	Caffeine Tannate Determined.	Tannin Combined with Caffeine.*	Caffeine Combined with Tannin.*	Total Tannin Determined.	Total Caffeine Determined.	Caffeine Not Combined with Tannin.	Tannin Not Combined with Caffeine.	Brokers' Price per Pound.†
								Cts.
Indian.	8.54	6.41	2.13	6.80	2.56	0.43	0.39	15
"	8.88	6.66	2.22	5.88	2.22	—	—	16
"	10.32	7.74	2.58	7.39	2.88	0.30	—	16½
"	11.48	8.61	2.87	8.41	3.52	0.65	—	17
"	13.28	9.96	3.32	9.24	3.70	0.38	—	21
"	9.60	7.20	2.40	8.73	3.20	0.80	1.53	23
"	12.50	9.40	3.10	9 50	4.00	0.90	0.10	45
"	13.36	10.02	3.34	10.92	4.32	0 98	0.90	45
Ceylon.	8.88	6.66	2.22	6.30	2.80	0.58	—	17
"	9.12	6.84	2.28	7.14	3.04	0.76	0.30	21
"	10.40	7.80	2.60	9.82	2.96	0.36	2.02	21
"	11.76	8.82	2.94	8.82	2.96	0.02	—	21
"	13.28	9.96	3.32	9.66	4.00	0.68	—	26
"	12.00	9.00	3.00	8.40	3.60	0.60	—	32
China.	5.36	4.02	1.34	3.02	1.92	0.58	—	13
"	5.60	4.20	1.40	4.87	2.72	1.32	0.67	16
"	7.60	5.70	1.90	5.04	2.72	0.82	—	19
"	6.32	4.74	1.58	3.96	2.72	1.14	—	26
"	6.48	4.86	1.62	4.60	2.80	1.18	—	34

* Calculated. † English prices.

When we come to China teas there is again seen to be some relation between price and the percentage of caffeine. A cheap China tea, for example (13 cents) per pound, gives 1.92 per cent of caffeine, while one at 34 cents per pound yields 2.80 per cent. China teas, again, rarely yield an excess of tannin, but nearly always an amount of caffeine in excess of tannin, and caffeine appears to occur in China tea with some constituent other than tannin.

BLENDS AND THE BEHAVIOR OF TEA WITH DIFFERENT WATERS.

So far we have been dealing with individual teas, but we now come to a consideration of blends. The aim of the blender is of course to produce a palatable tea and, more than that, to mix individual teas so that the whole shall be adapted to the peculiar requirements of different public water supplies. In doing this, does he unconsciously produce a mixed tea in which, whatever the drawbacks of the individual teas may be, a balance of caffeine and tannin somewhere near the ratio of 1 to 3 is effected? It is well known to tea experts that a tea which produces a pleasant palatable infusion with London water may easily be uninteresting or even possibly bad when made with, say, a very soft peaty water in Dublin or with the soft-water supplies of Plymouth, Aberdeen, Swansea, and elsewhere. The consumer has the same experience. He will have made up his mind after considerable trial that a certain tea in his judgment is best, at any rate at home. So convinced is he that the tea is a good one that when he happens to travel he will take care to have the same tea with him only to find out that outside his own district at home the tea becomes indifferent. In other words, he has found a tea which associates perfectly with the home supply of water, but which proves to go badly with waters of different quality. Hence the taster will always be careful to select a tea suited to a particular place, and it is invariably his plan to be sure of this by testing the tea with the actual water supplied to the neighborhood for which the tea is required. It is difficult to see here what guides him in this matter except it be flavor. The probability is that rich teas are more suitable for soft acid waters than for chalky waters. We know, at any rate, that an acid water will tend to neutralize the alkaline salts in tea which keep tannate of caffeine in solution; it would tend to throw caffeine and tannin in the form of tannate out of solution, and so weaken the infusion, whereas chalky water would have the opposite tendency and draw closely upon the available tannin and caffeine which are present in the form of tannate. This is a mere suggestion which may find little support in practice, but so far as we have examined blends deemed to be suitable for certain water the choice appears to be in the direction we have indicated. Thus in a blend intended for consumption in Dublin, where the water is soft and acid from the peat, the total caffeine tannate amounted to 13.20 per cent the caffeine and tannin being approximately in the 1 to 3 proportion, whereas a tea supplied to districts in Scotland where the water is soft but not acid the total caffeine tannate amounted to 8 per cent, and a tea for Wales, where the water is again soft but not so acid as Dublin water, the caffeine tannate amounted to 10.40 per cent, while the blends supplied for chalky waters showed amounts of caffeine tannate varying from 10.4 to 11.60 per cent.

In all cases it is interesting to observe that the blends showed a near approximation to the ratio of 1 to 3 of caffeine and tannin as in caffeine tannate, and whatever the individual requirements of different districts may be, the taster seems to know when and how a combination of teas will give a satisfactory result. The varying alkalinity of teas may probably be a factor in the case. What exactly lies behind the choice of a tea to suit the requirements of different districts is a theme which is difficult to pursue on merely chemical grounds, for in addition to the varying chemical characteristics of different water supplies, there are colonies of people who collectively like a strong pungent liquor, while there are others who prefer their tea to be light and delicate in character.

METHODS OF ANALYSIS.

The estimate of caffeine tannate.—In all cases the infusion was prepared by taking 5 grammes of tea and pouring upon the leaves just boiling water to 400 cubic centimeters and leaving the infusion to stand five minutes. It was then filtered. For the estimation of caffeine tannate 200 cubic centimeters of infusion was just acidified with dilute sulphuric acid and then saturated with ammonium sulphate and kept cold. The fluid was then filtered and the filtrate kept for the extraction with ethyl acetate of an excess of tannin that might be present, or of caffeine by means of chloroform. (It may be noted that a very rapid method of ascertaining whether tea infusion contains an excess of tannin consists in saturating the infusion with ammonium sulphate and filtering. The filtrate will contain any tannin present in excess of caffeine tannate which can be extracted by shaking with ethyl acetate separately and evaporating to dryness.) The precipitate in the filter was allowed to dry as much as possible in a current of air. The filter and its contents were then exhausted with a mixture containing 1 part of alcohol and 2 parts of benzene. The extracts were added together and made up to a definite volume (100 cubic centimeters). A known measure of this (25 cubic centimeters) was evaporated upon a weighed amount of lead oxide (approximately 3 grammes), keeping the mixture thoroughly stirred. The dry mass was then made into a paste with water and extracted several times with chloroform. The chloroform, evaporated carefully to dryness, gives the caffeine in the caffeine tannate. The lead residue was then carefully dried at 120 deg. Cent, and weighed to constant weight. The increase in weight gives the tannin extracted by the lead oxide. Another portion of the benzene-alcohol solution 25 cubic centimeters) is evaporated to dryness to give the total caffeine tannate.

The estimation of total tannin.—We found that good and consistent results were obtained by taking 20 cubic centimeters of the fresh infusion, adding slight excess of bicarbonate of soda and running in N/10 iodine solution until some petroleum ether shaken after each addition with the mixture showed a slight excess of iodine present by the well-known violet color. The factor for tannin was each cubic centimeter of N/10 iodine used multiplied by 0.0021.

Estimation of the total caffeine.—This was estimated by first slightly acidulating the infusion with dilute sulphuric acid, then boiling with an excess of lead oxide. After half an hour or so a clear pale yellow fluid results which filters perfectly, and can then be several times extracted with chloroform, which on evaporation yields caffeine.

A New Method for Preserving Meat

A RUSSIAN named Devel has recently introduced a considerable improvement in the so-called Morgan method of preserving meat. This method consisted in injecting into the main artery of the slaughtered animal an aqueous solution of 33 per cent sodium chloride and 30 per cent saltpeter, the function of which is to act as an antiseptic or preservative. This method is of course patterned after the model of the ancient Egyptian embalming process.

According to the Devel modification of this method, the solution is not pumped in all at once, but in a pulsating maner, imitating the heart action. A copper tube is introduced into the right ventricle of the heart, and the blood is thus gradually and completely washed out from the carcass. The operation is complete when, on severing the carcass at any point, the liquid which issues is perfectly colorless.

The process occupied a matter of only four to seven minutes, and consumes about four to six bucketfuls of the solution. The meat is laid in barrels which are filled with the same solution as that employed for the embalming process.—*Umschau.*

American Textbooks in China.

THE desire of Chinese to learn English, the lack of adequate textbooks in their own language, and the marked superiority of American schoolbooks have combined to make a fair market in China for the American publisher. Several leading American firms are well known already in Chinese schools, and their local agents are making constant efforts to extend their business. At present, however, there exists considerable doubt as to the efficacy of our treaties with China to prevent wholesale "piracy" of American textbooks by local Chinese publishers who, with their cheap material and abundant and inexpensive skilled labor, are able to perfectly imitate the American books and put them on the market at a figure considerably less than the cost price to the American publisher. Until this point has been settled in favor of the United States the sale of American textbooks in China will be beset with much uncertainty and many difficulties.—*Consular and Trade Report.*

Somatology and Man's Antiquity*

A Critical Review of Some of the Principal Finds of Fossil Man

By George Grant MacCurdy

AMONG the proofs of man's greater antiquity, his anatomical remains properly dated and determined, are the most likely to be uncontroverted. The greatest interest attaches therefore to the location and physical nature of human remains of unquestioned antiquity.

Fig. 1.—Lower Jaw of Homo Heidelbergensis—About ¾.

For this reason and in view of continued important discoveries, an occasional revision of the evidence and of theories based thereon is essential.

Ever since the discovery of fossil human bones at Forbes Quarry, Gibraltar; at Neandertal, Germany; and Spy, Belgium, interest in the somatological characters of our ancestral races has been keen. Discoveries of the past few years have added much to our knowledge of this subject. Because of the stratigraphic position in which it was found and of its osteological characters, the human lower jaw discovered by Dr. Otto Schoetensack on October 21st, 1907, in a sandpit near the village of Mauer, ten kilometers southeast of Heidelberg, ranks as the most important single specimen. Mauer lies in the valley of the Elsenz, a tributary of the Neckar. The human lower jaw was found *in situ* in the so-called Mauer sands, at a depth of 24.10 meters and 0.87 meter from the bottom of the deposit. The first 10.92 meters at the top of the section are composed of loess, which is classed as upper Quarternary, while the Mauer sands forming the rest of the section are lower Quaternary. The loess itself represents two distinct periods, an older and a younger.

The absence of chin and the simian character of the ascending ramus immediately attract one's attention. The ramus is characterized by unusual breadth, 60 millimeters as opposed to an average of 37 for recent examples. The angle formed by lines tangent to the basis and the posterior border of the ramus is 107 degrees—smaller than the average. The processus coronoideus is exceedingly blunt, and the incisura mandibulæ correspondingly shallow. The condyloid process is noteworthy on account of the extent of articular surface, due to an increased antero-posterior diameter (13 and 16 millimeters) since the transverse diameter is relatively short. The neck constriction is very slight, approaching in this respect the anthropoid forms. The teeth, however, have a distinctly human stamp, not only in their general appearance, but also in point of size—larger than the average, but smaller than in exceptional cases to be found among the Australians, for instance. One is impressed, in fact, by the relative smallness of the teeth as compared with the massive jaw in the case of *Homo heidelbergensis*. The crowns of the teeth are worn enough to show the dentine, proof that the individual had reached the adult stage. All the molars, except the third left, have five cusps. The tendency in recent man is toward a four-cusp type for the third molar, if indeed there be a third molar. The breaking away of the crowns of four teeth on the left side tended to facilitate the study of the pulp cavities and the walls. This study reveals the fact that the dentition of *Homo heidelbergensis* represents a youthful stage in the dentition of the modern European. That is to say, in the ontogeny of the latter, a stage representing adult dental characters when the race was young is now reached at the age of from nine to fourteen years. This is not an anthropoid character, but a primitive human character. As pointed out by Prof. Keith, the rotatory or side-to-side movement of the teeth, which distinguishes man from anthropoids, is already evolved in the Mauer specimen.

The lower jaw is an essential part of the mechanism of speech. In that of Heidelberg the form is not well adapted for the purpose in question and could have responded only to a primitive stage in the evolution of language.

It is unfortunate that the remains found near Heidelberg and at Trinil, Java, are so fragmentary. Both belong to nearly the same geological horizon. The femur of *Pithecanthropus* is distinctly human in form, suggesting the erect posture. The cranial cap on the contrary, is of an intermediate type; the brain in point of size is also intermediate between that of the average human and the anthropoid. Luckily the teeth offer a means of direct comparison between the Trinil and Mauer types. These are the last upper molar of *Pithecanthropus* and the last lower molar of *Homo heidelbergensis*. The two correspond in point of size. According to Keith, "the system of mastication was certainly the same in both and the palate of one was probably not very different from that of the other. The Heidelberg jaw, however, seems too massive and large to be fitted to the calvarium of *Pithecanthropus*."

The position of the Mauer lower jaw near the bottom of the old diluvium, and its association with the remains of *Elephas antiquus* and *Rhinoceros etruscus*, suggest for it a place at least as far back as the lower Quaternary. But the industry of the lower Quaternary is eolithic, the evolution of the Chellean type not taking place until the middle Quaternary. One would expect to find Mafflean industry in the horizon of *Homo heidelbergensis* and this, according to the latest report, is what Prof. Schoetensack has succeeded in doing.

Because of its good state of preservation and its primitive characters, the skull found in 1848 at Forbes Quarry, Gibraltar, might well have been a direct descendant of the Heidelberg man. According to Prof. Sollas it was a female of the Neandertal race. On the contrary, Keith thinks that its sex cannot be definitely determined and that its peculiar features, especially the low cranial capacity, are better explained by supposing it to belong to an earlier and more primitive human type than the Neandertal race.

The discovery one year ago by Mr. W. L. H. Duckworth, of a Mousterian industry in a cave near the one in which the Gibraltar skull was found may be considered as possibly throwing some light on the age of that relic. The human femur recently presented to the Royal College of Surgeons by Col. Verner comes also from a cave in the neighborhood of Gibraltar. The associated faunal remains prove it to have belonged to an ancient race.

The human teeth discovered last year by E. T. Nicolle and J. Sinel in a cave on the cliffs of St. Brelade's Bay, south coast of Jersey, belong to one of the most primitive examples of the Neandertal type yet known. According to Keith the teeth are fossilized and morphologically are intermediate between the teeth of the Heidelberg man and those of the Gibraltar specimen. That the teeth of early Pleistocene man were already highly specialized both as to roots and crowns is proved by the Heidelberg jaw. This Keith explains by the supposition that the human method of mastication had been evolved from the anthropoid long before the end of the Pliocene period.

The Heidelberg type, although somewhat sharply attenuated to be sure, persisted in Europe for a long time, most of the remains having been found in the Mousterian horizons. To this attenuated type is generally given the name *Homo primigenius*. In addition to the Forbes Quarry skull, this group includes the well-known remains from Neandertal, Spy, and Krapina. Some of the most recent finds are not only well dated but also include remains in an excellent state of preservation. In this class belongs the skeleton of a youth found by O. Hauser in the lower cave at the classic station of Le Moustier (Dordogne). The associated industrial remains are of the Mousterian type.

One of the best specimens of *Homo primigenius* was found in 1908 near the village of La Chapelle-aux-Saints, 22 kilometers south of Brive (Corrèze) by the Abbés J. and A. Bouyssonie and L. Bardon. The discovery was made just inside the entrance to a cavern which also yielded stone implements and remains of the bison, reindeer, fox, horse, and rhinoceros.

The human bones include the cranium and lower jaw (broken, but the pieces nearly all present and easily replaced in exact position), a few vertebræ and long-bones, several ribs, phalanges and metacarpals, clavicle, astragalus, calcaneum, parts of the scaphoid, ilium, and sacrum. The ensemble denotes an individual of the male sex, whose height was about 1.60 meters (5 feet 3 inches). The condition of the sutures and of the jaws prove the skull to be that of an old man. The cranium is dolichocephalic, with an index of 75. It is said to be flatter in the frontal and occipital regions than those of Neandertal and Spy.

Beyond the loss of teeth, due evidently to old age, the skull is so nearly intact as to make possible the application of the usual craniometric procedure, thus leading to a more exact comparative study than has been possible in all previously discovered paleolithic human skulls dating from the same period. This is particularly true of the basi-occipital region, the upper jaw, and the face-bones. We are thus en-

Fig. 2.—Lower Jaw of Homo Heidelbergensis. After Schoetensack, Der Unterkiefer des Homo Heidelbergensis. Leipzig, 1908.

* Reproduced by courtesy of *Records of the Past*.

Fig. 3.—Skull of the Fossil Man of La Chapelle-aux-Saints, After Restoration of the Nasal Bones and Jaws, After Boule.

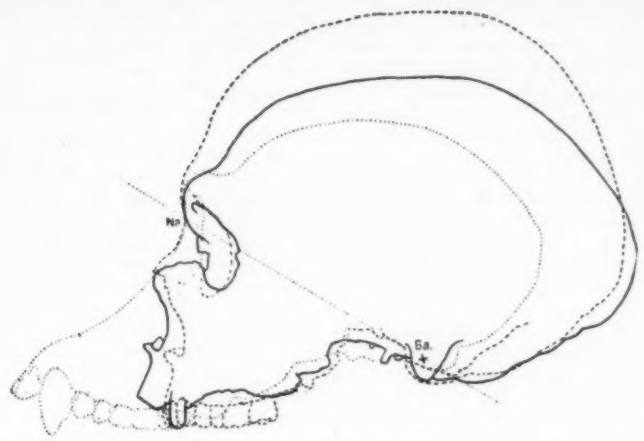


Fig. 4.—Profiles of the Cranium of a Chimpanzee, the Cranium of La Chapelle-aux-Saints, and that of a Modern Frenchman Superposed, and With a Common Basi-nasal Line Equal in Length for Each. Ba., Basion; Na, Nasion. After Boule.

abled to supplement our knowledge of Mousterian craniometry at several points and to correct it at others. This is the first case, for example, in which the foramen magnum has been preserved in human crania of the Mousterian type. It is found to be elongated, and is situated farther back than in modern inferior races. The character of the inion and its relation to the cranial base is revealed for the first time. There is no external occipital protuberance, but the linea nuchæ superior (torus occipitalis transversus) is well marked. The character of the surface in the nuchal region indicates that the muscles here were highly developed. The palate is relatively long, the sides of the alveolar arch being nearly parallel; that is to say, the palate is hypsiloid, one of the two characteristic simian forms. Boule also notes the absence of the fossa canina. The nose, separated from the prominent glabella by a pronounced depression, is relatively short and broad. The lower jaw is remarkable for its size, for the antero-posterior extent of the condyles, the shallowness of the incisura mandibulæ, and the absence of chin.

Boule estimated the capacity of the Chapelle-aux-Saints skull according to the formulæ of Manouvrier, of Lee, and of Beddoe, obtaining results that varied between 1,570 and 1,750 cubic centimeters. By the use of millet and shot an average capacity of 1,626 cubic centimeters was obtained. Judging from these figures the capacity of the crania of Neandertal and Spy has been underestimated by Schaaffhausen, Huxley, and Schwalbe. By its cranial capacity, therefore, the Neandertal race belongs easily in the class of *Homo sapiens*. But we must distinguish between relative capacity and absolute capacity. In modern man, where the transverse and antero-posterior diameters are the same as in the skull of La Chapelle-aux-Saints, the vertical diameter would be much greater, which would increase the capacity to 1,800 cubic centimeters and even to 1,900 cubic centimeters. Such voluminous modern crania are very rare. Thus Bismarck, with horizontal cranial diameters scarcely greater than in the man of La Chapelle-aux-Saints, is said to have had a cranial capacity of 1,965 cubic centimeters.

The most remarkable thing about the astragalus is the special development of the articular surface for the lateral malleolus, development that recalls the condition in anthropoids and climbing mammals. This seems to indicate that, as among anthropoids, the foot of the man of La Chapelle-aux-Saints should repose on its external margin, also that the fibula was relatively more powerful than is the case among modern races. The calcaneum is characterized by its shortness and especially by the large dimensions of the lesser process (sustentaculum tali). The latter in its proportions resembles that in the Veddahs and in anthropoids.

Profs. Boule and Anthony after an exhaustive study of the encephalon of the Chapelle-aux-Saints skull arrive at conclusions to be summed up as follows:

Human characters: Large absolute volume; predominance of left hemisphere, indicating right-handedness (according to Bardeleben, orangs are right-handed, while gorillas and chimpanzees are left-handed); presence of two pre-sylvian branches; presence of an opercular system similar to that in man.

Intermediate or simian characters: General form; general simplicity of the convolutions; position and direction of the fissures of Sylvius and Rolando; distinctness and length of the parieto-occipital fissure; reduced frontal lobes, particularly in their anterior region; accentuation of the encephalic rostrum; primitive character of the third frontal (Broca's convolution, the seat of articulate speech); presence of a well-developed sulcus lunatus (simian groove, Affenspalte), according to Elliott Smith an incontestable index of inferiority; separation of the cerebellar lobes, exposing the vermiform process; direction of the medulla oblongata (more oblique from the front toward the back than in modern man, but less so than in anthropoids).

In short Boule and Anthony find the encephalon of the man of La Chapelle-aux-Saints to be a real human brain, on account of the mass of cerebral matter; but this matter still lacks the superior organization that characterizes modern man.

During the autumn of 1909 M. D. Peyrony, of Les Eyzzies, had the good fortune to discover human remains of Mousterian age at two different localities in the department of Dordogne. The first find was made in a small cavern at Pech de l'Azé, five kilometers from Sarlat. Here in undisturbed upper Mousterian deposits was found the skull of a child five or six years old. About it were the numerous animal bones broken artificially, the teeth of the horse, deer, reindeer, and an abundance of Mousterian implements. The lower Mousterian deposit on which the skull rested contained fine implements of the Acheulian type.

M. Peyrony's second discovery was made in the rock shelter of La Ferrassie near Bugue. La Ferrassie is a vast rock-shelter, whose ceiling fell before the close of the Quaternary. The various deposits are intact and easily distinguished by their color: each contains a stone industry, also bone objects, and fossil remains. The section at La Ferrassie comprises five archeological horizons: Acheulian, Mousterian, and lower, middle, and upper Aurignacian. It was between the Acheulian and Mousterian deposits and at a depth of three meters that an almost complete human skeleton was found. The associated fauna includes the mammoth, horse, reindeer, and *Rhinoceros tichorhinus*. Although in part crushed by the enormous weight of earth above, all the bones were in place with the exception of those of the right hand and foot, which had been displaced and partially destroyed, probably by some carnivore or rodent. The skeleton has been removed intact. Unlike the case of La Chapelle-aux-Saints, this was not an interment. The body was placed at one corner of the shelter and covered with branches or skins, perhaps a little earth, or all three of these combined. About the head and shoulders were three stones that might have served as weights. Gradually it was covered deeper and deeper by débris from the overhanging rocks and that left by succeeding Aurignacian populations. Its stratigraphic position is clearly defined. In 1910, M. Peyrony had the good fortune to find another human skeleton at La Ferrassie in the same horizon as the one discovered the previous year. The two skeletons were only one-half meter apart, vertex against vertex; and in both the legs were sharply flexed, the knees being drawn toward the chest; the elbows seemed to rest against the knees. The body had been placed on the right side and in the same axis as the other. The lower extremities are well preserved, but the skull was crushed. A more extended report as to the somatological characters of these two skeletons from La Ferrassie is awaited with much interest. It should not only confirm but also supplement existing data bearing on the osteology of *Homo primigenius*, as did the remains from La Chapelle-aux-Saints. All three specimens are now in the Paris Museum of Natural History. The latest report from the French caverns is that only a few weeks ago, Dr. Henri Martin discovered a nearly complete human skeleton in the Mousterian deposit at La Quina (Charente).

The Dordogne seems destined to maintain its lead in matters of palæolithic. Herr O. Hauser, who made the important discovery of *Homo mousteriensis* at Le Moustier in 1908 was also rewarded with a rich harvest in 1909. At Combe-Capelle, near Montferrand-Périgord, he found on August 26th an adult male skeleton of Aurignacian age. The type, however, is of a higher order than that of his *Homo mousteriensis*, the difference being greater than might be inferred from its stratigraphic position. The remains had been interred, the pit being sunk into a deposit of Mousterian age. The stone implements found with the skeleton about the head, arms, knees, and feet are Aurignacian. For this reason Klaatsch suggests the name *Homo aurignacensis hauseri*. A number of small shells were also deposited with the dead, probably as ornaments. Klaatsch classes *Homo aurignacensis hauseri* with the human remains from Brünn (Mähren) and Galley Hill, near London. All three skulls are long and narrow, markedly dolichocephalic; the other skeletal parts agree in type. Klaatsch also notes certain resemblances to the much later Magdalenian race, as represented by the skeleton found twenty years ago at Chancelade, also in the Dordogne. Although of rather short and powerful build, Klaatsch believes this Aurignacian race did not evolve directly from the Neandertal or Mousterian race.

Fig. 5.—Skull of Homo Aurignacensis Hauseri, Front View.

Fig. 6.—Skull of Homo Aurignacensis Hauseri, Profile.

If the Galley Hill skeleton is properly dated, and there is room for doubt on this point, we have the interesting phenomenon of two somatologically distinct races existing side by side in Europe for a long space of time Such a possibility invests the Galley Hill find with new interest. According to Messrs. R. Elliott and Matthew Heys who found the nearly complete skeleton in 1888, it was *in situ* and came from a depth of more than eight feet in Pleistocene high-level (so-called middle terrace) river drift, which at Galley Hill is 90 to 100 feet above the Thames. Prof. Sollas believes the skeleton to be as old as the gravels and not an interment. The Galley Hill section reveals eight feet of gravel and sands, under which is a clay deposit two or three feet thick. The skeleton was found in the clay deposit. According to Rutot this is the Strépyan horizon. In fact it furnished a mixed industry, including Strépyan as well as Chellean and Acheulian forms. Assuming that the Galley Hill man is as old as the deposit in which it was found, Keith attempts to measure its antiquity by the work done by the Thames since its high level-terrace was formed. An elevation of the land has caused the river to wear down its valley nearly 100 feet. But the whole amount of erosion is not accounted for without adding the 40 or 50 feet that were cut below the present level and later filled up. The lowering and filling combined thus amount to about 175 feet. On the basis of the change in valley level which has taken place since Roman times, Keith feels justified in allowing "1,000 years for every foot which the river has worn away or laid down." He thus arrives at an antiquity of 170,000 years for the Galley Hill remains.

Osteologically the Galley Hill man is much more closely related to the modern European than is *Homo primigenius*. He was of short stature and had a well-developed muscular system. A cranial capacity of 1,360 cubic centimeters is a good average for one of his stature; a cast of the cranial cavity is said by Keith to reveal a highly convoluted brain essentially modern in aspect. A peculiar feature of the cranium is its extreme dolichocephaly. The ilium is distinctly that of *Homo sapiens*.

The marked racial differences between the Neandertal and the Galley Hill type lead Rutot to believe that the men of Neandertal, Spy, Krapina, Le Moustier, and La Chapelle-aux-Saints are descendants of the primitive eolithic race with stagnant mentality represented at present by *Homo heidelbergensis* and possibly *Pithecanthropus erectus;* while at the close of the lower Quaternary there appeared a new race with progressive mentality represented by Galley Hill and later by Combe-Capelle and Brünn, to whom we owe the palæolithic industry. So that during the lower palæolithic there were two types of mankind in Europe: the waning eolithic type and the Galley Hill type, the latter becoming dominant in the upper palæolithic, and passing into the Cro-Magnon type before its close.

It was while making a careful study of the Aurignacian skeleton from Combe-Capelle that Prof. Klaatsch formulated his interesting theory concerning the origin of the human race. He points out certain osteological features common to the gorilla, the Heidelberg man and the Neandertal races; all three he supposes to have sprung from the same stock. On the other hand, he finds features common to the Galley Hill or modern type and the orang, and concludes that they descended from the same stock. The resemblances to which Klaatsch calls attention are certainly striking and he deserves much credit for bringing them out so clearly. One should not, however, lose sight of the myriad characters possessed in common by the Neandertal and Galley Hill races; these are too numerous to be explained away as "convergence phenomena." Prof. Klaatsch's theory has found little favor either at home or abroad. In fact, Keith who has made complete dissections of more than eighty anthropoids regards the orang as the least likely of all the higher primates to give rise to the human race. On the other hand he looks upon the chimpanzee and especially the gorilla as "descendants of a stock from which it is not difficult to suppose the primary human stock may have arisen."

Thus far the evidence bearing on the greater antiquity of man has been gleaned from the Old World. That which the New World has to offer may be dismissed in a few words as still being far from satisfactory. In a recent paper on "Skeletal Remains Suggesting or Attributed to Early Man in North America," Dr. Ales Hrdlicka, the somatologist of the United States National Museum, concludes that "thus far on this continent no human bones of undisputed geological antiquity are known." As regards South America, Ameghino *et al.* believe certain fire products found in the lower Pampean deposits of Monte Hermoso to have a human origin. A human atlas was also found in these deposits. To the fire-maker Ameghino gives the name *Tetraprothomo*. On the other hand, in the opinion of Outes, Lehmann-Nitsche, Steinmann, and others these fire products are simply volcanic scoria. Hrdlicka and Bailey Willis, who recently visited the region in question, are of the latter opinion; as is also Prof. Boule, whose studies of similar volcanic phenomena in south central France adds special weight to his conclusions. Somatologically the human atlas which came from the lower Pampean deposits differs but little from those in modern man of the same region; and the age of the deposits themselves has not yet been determined with any degree of accuracy.

The Physical Properties of Cast Iron*

Their Relation to Chemical Composition and Blast Furnace Operation

By John Jermain Porter, Metallurgical Engineer, University of Cincinnati

IT is perhaps not too much to say that the adoption of chemistry by the foundry has been responsible for a large part of the amazing advance of this industry during the past decade. Within this period mixing by analysis has become the rule rather than the exception, and so much has been published and is now available along this line that further discussion seems superflous. There is, however, a related point in connection with the selection of pig iron for the mixture, which has thus far received scant attention, but which is, in my opinion, worthy of most earnest consideration by foundrymen, and perhaps even more so by iron merchants and manufacturers. I refer to the great difference which exists in the behavior of many brands of pig iron and which apparently cannot be accounted for on the basis of chemical composition as ordinarily determined.

In former days, now happily past, the old time founder, innocent of chemistry, swore by brands and possessed as part of his stock in trade a list of such as had proved in his experience satisfactory and unsatisfactory. To the chemist this was ridiculous. From his standpoint two irons having the same composition must have the same properties and give the same results, irrespective of brand name or anything else, and so earnestly has this doctrine been preached that his theory has won very general acceptance. It is far from my intention to belittle the value of chemistry in the foundry or to deny the utility of analysis as a means of judging of the quality and fitness of an iron. Nevertheless, I must take exception to the view still held by many chemists that analysis is everything, and maintain that there is something to be said for the arbitrary preferences of the older generation of founders. I believe it to be the case that there are many irons which have practically identical analyses and yet show marked differences in such important properties as strength and shrinkage, and I will now offer what evidence I have to support my views on this point.

EVIDENCE AS TO PIG IRON DIFFERENCES.

Perhaps the most convincing evidence that has come to my notice is contained in a paper entitled: "An Introduction to the Effect of Structure Upon the Physical Properties of Cast Iron," presented by F. J. Cook and G. Hailstone before the British Foundrymen's Association in 1909. In this paper it is recorded that of two mixtures practically identical in chemical composition, the one was invariably much lower in tensile strength than the other, and this difference persisted through a great many heats and over a long period of time. The poorer mixture averaged about one-half of the strength of the better mixture, and in none of the 60 cases given is the strongest bar of the poor iron equal to the weakest bar of the good iron. The following analysis and tests are given as typical of the series, and in view of the exceedingly close agreement of these analyses it is evident that we must look elsewhere for the cause of the very great difference in strength.

	A.	B.
Tensile strength, tons per square inch	9.1	18.3
Total carbon	3.250	3.092
Graphitic carbon	2.397	2.289
Combined carbon	0.853	0.903
Silicon	1.328	1.314
Sulphur	0.095	0.101
Phosphorus	0.923	0.909
Manganese	0.290	0.335
Iron, by difference	94.114	94.149

A few years ago I was called into consultation by a certain foundry regarding a persistent case of trouble with shrink holes in small chunky castings. It had been found by the foundry superintendent that the extent of the trouble apparently bore some relation to the mixture used, and hence experiments were carried out to determine what constituent or constituents were responsible for the difficulty. I am not at liberty to give full details of the results of these tests, but an outline of the experiments is as follows:

There were six brands of pig iron on the yard at the time, representing both Northern and Southern irons. Each of these irons was melted separately by using it alone in the first charge and separating the rest of the day's heat by a blank of coke. Working in this way some twenty of the small castings which had given the greatest trouble were poured from each kind of iron. All conditions were kept as uniform as possible and the experiments were repeated several times with different lots of the various irons to minimize the danger of accidental interference of other factors. Finally, the castings were examined for shrinkage cavities, with the following results:

Brand No. 1.—Castings all good; not a shrink hole in the lot.

Brand No. 2.—Fifty per cent perfect castings, 50 per cent with small trace of shrinkage.

Brand No. 3.—Ten per cent perfect castings, 90 per cent with small trace of shrinkage.

Brand No. 4.—None perfect; all showed a little shrinkage.

Brand No. 5.—All castings with small shrinkage cavities.

Brand No. 6.—All castings very bad, with large shrink holes.

All of these irons were the ordinary No. 2 and No. 3 foundry grades, and while there was some variation in the analyses there is absolutely no traceable connection between the percentage of any element or combination of elements and the results as to shrinkage. Moreover, the irons were each completely analyzed by a competent chemist and it was determined that the difference in behavior could not be attributed to the presence of any unusual elements or to unusual variations in the proportions of the carbons. Since these original experiments were carried out, others have been made on various mixtures of these brands, and it has been shown that the behavior of any mixture is approximately proportional to the behavior of its constituents, so that with equal parts of Nos. 1 and 6 most of the castings will show just a little shrinkage. It has also been found that the remelt from these irons affects the shrinkage in much the same way as the original pig.

It is quite well known among both foundrymen and blast furnacemen that pig iron made in whole or in part from "mill cinder" is less desirable than that made entirely from ore, although the use of the mill cinder will not, as a rule, change materially the composition of the pig. The points of inferiority of cinder pig do not seem to be very clearly defined and have probably never been scientifically investigated. Nevertheless, they are real enough to affect its sales value, and in England are recognized by the creation of the grades of "cinder pig" as opposed to "all mine pig." I have had some experience in the use of mill cinder in the blast furnace and have noticed that when using a considerable proportion of it the iron was noticeably easier to break on the blocks, and there was invariably a decided increase in the unreduced iron in the slag.

CHARCOAL AND COKE PIG IRON.

Again we have the case of charcoal iron, which in spite of the threats of foundry chemists to drive it from the field, is still produced in this country to the extent of some 400,000 tons per year, and is still regarded as indispensable for many classes of work. As far as analysis goes there is but little average difference and no essential difference between charcoal and coke iron. Charcoal iron averages lower in sulphur, but any coke furnace can and often does produce iron with the sulphur down under 0.01 per cent, which is as good as is expected from charcoal iron. Again charcoal iron averages somewhat lower in total carbon than most coke irons, but here again the difference is not universal, and, if we should judge by analysis only, many coke irons could easily pass as the product of the charcoal furnace.

Coming to the properties of the two kinds of iron, however, it is within the experience of almost every foundryman that there is a difference. This is perhaps most generally noticed in the matter of toughness or strength, which in charcoal iron is much greater, the grains having a tenacity which causes the iron to tear to a marked degree rather than breaking off short. It is also noticed, however, in the properties of shrinkage, tensile strength and depth and character of chill, and since there is such a difference in properties and such a similarity in composition I think it safe to say that we

* A paper read at the recent meeting of the Pittsburgh Foundrymen's Associations.

have here a notable example of that elusive difference which escapes the arts of the chemist.

Finally, I might cite the experience and opinions of many competent foundrymen who have found the facts to be as I have stated. One authority in particular, Dr. R. Moldenke, has repeatedly called attention to these conditions, and if time permitted I might read many quotations from his papers confirming the facts which I have just brought out.

THEORIES IN EXPLANATION.

Although we may recognize the fact that differences in pig iron may exist which cannot be accounted for by analysis, the explanation of these differences is another and a very difficult matter. It is true that, as in the case of steel, the methods of metallography furnish a clue, and under the microscope the structure of cast iron often shows remarkable variations. Cook in the example first cited found that his strong iron showed under the microscope a peculiar network structure of the phosphide eutectis combined with much finer graphite than existed in the weak mixture. It is well known that charcoal iron is finer in grain than coke iron of similar composition and that this closer grain is an almost invariable accompaniment of strong iron. Hence we may assume that a part at least of the differences in pig iron is due to the variations in size, shape and arrangement of the graphite flakes This is all right as far as it goes, but is only pushing the matter back one step and is not satisfactory as an ultimate explanation. In seeking the real explanation, five possible theories have suggested themselves, and these I will take up in order.

1. The Manner of Cooling.

It has been known for many years that the rate of cooling is an important factor in determining the percentage of combined carbon, and lately it has become appreciated that it may also affect iron in other ways than through the combined carbon. For example, Custer, in his work with permanent molds, has shown that graphite size may be controlled without change in ultimate composition by varying the rate of cooling through the solidifying range; and others have found that hardness and electrical properties may be varied through quite wide limits by controlling the rate of cooling through a much lower range and without appreciably affecting the carbons. In my opinion this possibility is due to a change in the allotropic state of the iron which takes place at about 1,400 deg. Fahr. and which is not made evident by chemical analysis.

However, though granting that the manner of cooling may produce many important changes, I still cannot believe that this theory is competent to account for the examples previously given. In the case of both Cook's experiments and those coming within my own experience, rate and manner of cooling were as nearly similar as it was possible to make them, and the number of pieces tested was too great to permit of the possibility of a coincidence of accidental variations in this factor. Moreover, the persistence of the differences after the remelting of the irons cannot be explained on this basis.

2. Form of Combination of Constituent Elements.

Another theory which may possibly be thought by some to afford an explanation is the manner in which the elements of the pig iron are combined. There are six elements present in cast iron and some 12 or 15 constituents are possible through the different forms of combination of these elements. There is, however, nothing to indicate that there is anything in this theory, and even if we could account for it on this basis there would still be the question why two brands of the same elementary composition should have their elements combined in such different ways as to produce different properties.

3. Dissolved Nitrogen.

Of late years considerable attention has been given to the gaseous impurities of steel, and it has been found that nitrogen is a rather common and a very detrimental impurity. May it not be the case that the presence of more or less of this element (which is not determined in the ordinary analysis) explains the differences which I have described? This appears a more likely explanation than any of those thus far cited. I do not, however, regard it as the right one, or at least the chief one. There is very little evidence either for or against it, but such as there is appears to be against it. The well-known experiments of Braune (*Stahl und Eisen*, 1906) seem to indicate that nitrogen is seldom or never an important factor in gray cast iron, although it may be sometimes in white or chilled iron; and Gayley (*Trans.* A. I. M. E., 35, 986) has described some tests made on the nitrogen content of different classes of pig iron in which he found that there was apparently no relation whatever between the amount of nitrogen and the quality.

4. Dissolved Oxygen or Oxides.

Perhaps the most generally accepted theory to account for otherwise unexplainable differences in cast iron is to assume the presence of variable amounts of oxygen in the metal. This theory is due more especially to Dr. Moldenke, who in several papers has cited considerable evidence in its support. Perhaps the most conclusive evidence is the actual isolation of magnetic oxide, Fe_3O_4, from samples of iron which have been badly burnt on the hearth of an air furnace and which are known to have had the characteristics commonly attributed to oxidized metal. This theory fits in well with all that is known regarding the relation between blast furnace practice and the properties of the iron made. For example, mill cinder is a particularly difficult material to reduce, and, as before mentioned, it has a well marked detrimental effect on the quality of the pig iron produced. Still another example mentioned by Dr. Moldenke is the difference in quality between malleable Bessemer made in a lightly blown furnace and regular Bessemer made in a furnace driven to the limit.

5. Oxysulphides.

While accepting as probably substantially correct this last theory, I would suggest that possibly a modification of it may be still nearer the truth. It is generally assumed that the oxygen is present as dissolved oxide of iron, but it seems to me possible if not probable that it may be rather in the form of an oxysulphide of iron. This compound has been shown by Campbell (*Iron and Steel Inst. Jour.*, 1903) to be capable of existing in iron and steel at high temperatures and to have remarkable powers of diffusing through the solid metal. LeChatelier has also proved its existence.

The evidence as to its presence and influence in commercial iron and steel is only indirect, but there is some circumstantial evidence pointing in that direction. It is quite noticeable in blast furnace practice that following a slip bringing unreduced ore into the hearth there is a most evident association of badly oxidized iron and very high sulphur. It is also well known that it is particularly difficult to keep the sulphur down when smelting mill cinder.

In Lake's "Composition and Heat Treatment of Steel," page 82, I find the statement that steel which has been completely freed from gaseous impurities can be quite high in sulphur without its quality being apparently injured. Again in a paper by Herbert Pilkington on "Cast Irons for Foundry Purposes," read before the British Foundrymen's Association in 1911, it is stated that many of the best cold blast charcoal irons contain 0.10 per cent sulphur and up, and that this quantity, which would be ruinous to ordinary pig, does not in this case produce unsoundness or other bad effects. Finally, I know of several observant foundrymen who are quite certain that sulphur is sometimes much more injurious than at others, and this fact, if such it be, may or may not be caused by its association with variable amounts of oxygen in the form of oxysulphide.

THE EFFECT OF VARYING BLAST FURNACE PRACTICE.

Thus far my discussion has been largely academic. A more practical question is the relation between blast furnace practice and the presence in the pig iron of these injurious properties, however they may be caused. Unfortunately we have not enough data to draw exact conclusions, or, indeed, any conclusions. My observations have led me to accept as a tentative theory the rule that the less oxidizing the conditions under which the iron is made the better will be its quality. In other words, satisfactory iron should be made from easily reducible ores, with a moderate rate of driving and with not too much economy of fuel. These conditions, if correct, are rather hard on the furnaceman and it is to be hoped that further information may modify them somewhat. It is a significant fact, however, that in a large number of cases the irons having the highest reputation for low shrinkage and general good casting properties are made in small furnaces inadequately provided with blowing capacity and hence lightly driven, and using brown hematite or other easily reducible ore.

I have thus far been unable to determine whether those factors in the operation of the furnace which are within the control of the furnace manager have any important effect upon these properties of pig iron, but it is probable that to some extent they have. It is a well known fact that the grain of the pigs may be varied within wide limits without regard to composition by varying the basicity of the slag and the temperature of the hearth. It is also well known, however, that upon remelting the character of the grain is changed and becomes normal, and so far as I know, it has never been shown that the size of the grain in the original pig bears any relation to the properties of the iron after remelting—at least none which cannot be explained on the basis of composition.

On the other hand, I have noticed certain indications which lead me to believe that it is possible to accomplish something by the way the furnace is handled. For example, it appears that the bad effects of mill cinder may be at least partly nullified by slow driving and the use of some excess of fuel. Again, magnetic ore appears to make a satisfactory foundry iron, although it is very hard to reduce, but furnaces using it are generally driven rather slowly. Reasoning entirely from theory, it seems likely that the presence of ferrous silicate in the ore, the formation temperature of the slag (not the melting point), the temperature of the hearth and the freedom from slips may all have something to do with the quality of the iron. It would be interesting to follow up some of these points; for example to compare the iron made by the use of dry blast with that made under otherwise similar conditions but using moist blast. Dry blast greatly increases the hearth temperature, thus producing conditions identically opposite to those under which cold blast charcoal iron is made; yet it is quite possible that it may produce an effect of the same kind on the pig, although less in degree.

PRACTICAL APPLICATIONS.

The practical application of the facts which I have here tried to bring out may not seem to be of any great importance, but I am not so sure that this is the case. Some time ago I had a talk with a foundry superintendent of very broad experience, and in discussing the experiments on fluid shrinkage previously described he insisted that to many foundries this property is one of the most important and difficult problems and is responsible for a much larger number of defects than is generally supposed. According to this gentleman, the question of the influence of brands upon this property is well worth the study of the practical foundryman. There are, of course, many foundries where neither fluid shrinkage nor high strength is of any particular importance; but on the other hand there are some classes of work where one or both of these properties is of very great importance, and in such cases it appears to me that a knowledge of brand characteristics is almost indispensable.

As there is no published and very little privately held information along these lines, it is necessary for each founder to gather his own data, and the procedure which I recommend is as follows:

1. A fluid shrinkage and transverse strength test from each heat.
2. A continuous record of the results of these tests and the mixtures used.
3. Occasional tests of the different brands melted separately.

In regard to the test for fluid shrinkage I have found that originally recommended by Cook and consisting of a casting in the shape of a K with the legs about 1 inch square in section to be very satisfactory. When this casting is broken at the junction of the legs any tendency towards fluid shrinkage will be evident there. In using this test it is convenient to construct a scale consisting of a series of from four to eight broken K castings of varying degrees of badness. These are mounted in a box and given suitable numbers. Thereafter, it is sufficient to compare any test piece with this scale and record as its shrinkage the number on the scale most nearly resembling it.

It will be evident that obtaining these data need not be at all burdensome to the foundry undertaking it, since no special apparatus is called for, except a transverse testing machine, and the extra work involved will hardly amount to 20 minutes per day of a helper's time. Even the special tests of separate brands need not interfere with ordinary foundry routine since they can be run as the first charge in a regular heat.

Another conclusion which might be drawn from the facts brought out is that there is a great opportunity for some of the manufacturers and sellers of foundry pig iron to make strong selling points of these special virtues, once they have found them in their brands. I am quite convinced that the larger commission firms would find it very much to their advantage to have the properties of the brands they handle thoroughly tested so that they could sell them more intelligently. A pig iron salesman armed with this information and some foundry lore would indeed deserve a better name than the now sometimes given title of "hot air artist."

Finally it appears to me that the recognition of the injurious effects of the gaseous impurities in cast iron will give a fresh argument to the electric furnace man. I have long thought that it should be practicable to use an electrically heated receiving ladle or mixer in connection with either a blast furnace or cupola. Here the iron could be partly refined, treated with deoxidizing alloys, adjusted in composition and brought to any desired casting temperature. And since there would be no melting to do, the amount of electrical energy needed would be relatively small. Operated on a sufficiently large scale to take care of the fixed charges, it appears to me that this combination could be made profitable for some lines of work.—*The Iron Age.*

The Rate of Growth of Reef Building Corals

MR. F. WOOD JONES, during a stay upon the Keeling atoll has collected some careful observations on the rate of growth of corals. While measurements had been made by other observers, these are the first gathered under natural conditions, and over an extended period of time (100 days). Observations over shorter periods are unreliable, as the life of a coral is made up of alternating periods of accelerated growth and complete standstill. It was found that the massive forms increased in one hundred days by one-thirty-seventh of their size, branched species showed, in the same length of time, an increase of 1.079 inch, corresponding to 3.94 inches yearly.—*Prometheus.*

One-sided Partnerships in Nature

Where the Benefit is Not Mutual

By Benjamin C. Gruenberg

DURING the last third of the nineteenth century, when evolutionary thought was so largely dominated by the Darwinian theory of "Natural Selection," most investigators in natural history tried to bring their observations into line with the idea of *adaptation*, since only adaptive or "fit" characters are accounted for by Darwin's theory, or by unscientific ideas of "purpose." Many structures and habits of plants and animals are of no obvious advantage to their possessors, nor can they be accounted for as "rudimentary" or "vestigial." Some of these have strained the ingenuity of numberless clever men in seeking for a naturalistic explanation.

The curious incrustations found on rocks and old tree-trunks and called "lichens," consist of fungous threads entangling green algal cells. In 1879 the botanist DeBary applied the term "symbiosis" (literally, "living-together") to the relationship between the algal and the fungal elements in lichens. By this term he intended to convey at once the fact of *contiguity* and that of mutualism in the association. The idea then was, and has been since pretty generally accepted by most

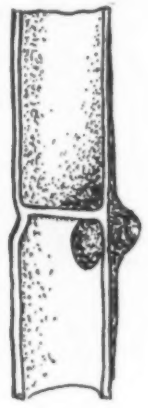


Fig. 1.—Stem of *Cecropia*, Showing the Glands That Attract Ants.

botanists, that the fungus absorbs from its substratum (or from the air) water and mineral matters that are worked over by the alga into substances that are then available as food for both members of the partnership. This idea of symbiosis has been extended by many workers to apply to various associations between plants, between animals, and between plants and animals.

Large numbers of the described cases have passed into biological literature and even into text books without having been critically examined until within very recent years, when it has been found that many of the best examples of *symbiosis* are altogether one-sided, so far as any advantage from the association is concerned. A number of these are interesting from the natural-history point of view as well as from the more strictly scientific.

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The classical cases of symbiosis between plants and ants were those described by Schimper for Cecropia in South America, and for Humboldtia in the eastern tropics. (Figs. 1 and 2.) In these plants the internodes of the stem (the regions between the "joints" or leaf-bases) are hollow, have openings to the exterior and are generally occupied by ants. The ants find good homes in these plants, and food; in return they protect the plants against attacks by other insects and destroy plant lice. Here then is an exchange of services which gives each partner distinct advantages; and this relationship accounts, from the point of view of natural selection, for the peculiar structures of the plants, including the nectar-secreting glands on the stems and leaves. Since the time of Schimper many observers have discovered hundreds of species of plants with hollow stems, with hollow swellings, with special openings into the hollow cavities, with extra-floral nectaries, with pockets in the leaves and with other peculiarities that seemed to make them well-adapted for attracting and harboring ants. (Figs. 3 and 4.) These plants were called "myrmekophilous" or "ant-loving" plants.

But within the last dozen years there have been made a large number of observations that would seriously shake this beautiful theory. Most of these newer observations were made by students of ants rather than by botanists, and this may account in a measure for the difference in the point of view developed.

Rettig was one of the first of these more critical students; he came to the conclusion that there are many ants that depend upon the plants for their food, or protection, but that there are probably no plants that depend in any way upon the ants. This view later found abundant confirmation from the studies of several naturalists. Three investigators went over the field very thoroughly in South America a few years ago, studying various plants including the Cecropia. These three—von Ihering, Ule and Fiebrig—independently came to the conclusion that not only are the ants absolutely unnecessary to the prosperity of the plants, but may even be harmful to them inasmuch as they either directly attract other enemies (as birds) or at least make possible the entrance of other insects and fungi. Fiebrig found for example that in many cases the openings made by ants served as portals for the entrance of certain caterpillars that eventually destroyed the invaded branch by their feeding operations. In other cases the presence of the vast numbers of ants in the tree attracted wood-peckers, which not only produced various mechanical injuries, but made openings that admitted other insects and destructive fungi.

The ant *Azteca*, therefore, which had been for years supposed to be an indispensable friend and ally of the *Cecropia*—so that the "Cecropia-Azteca symbiosis" was referred to as the typical case of mutualism between a plant and an animal—turns out to be a useless parasite. As von Ihering puts it, "the Cecropia needs the Azteca for its welfare, as the dog needs the fleas."

Quite similar are the conclusions of two students working on the Cecropia and other myrmekophilous plants in tropical Africa. The German Kohl and the Swede Sjöstedt (who was with the Swedish zoological expedition to Mount Kilimandjaro in East Africa) both found that the plants receive no real advantage from the presence of the ants, all the advantage being on the side of the ant—and to the *detriment* of the plant.

A Dutch investigator studied over sixty species of plants in Java with respect to the relationship of the extra-floral nectaries, which have been for so long accepted as "ant-attracting" organs without challenge. He finds that not in a single one of these species is the secretion of sugar-solution upon the leaves and stems of any advantage to the plant. On the contrary, in many cases they are injurious, since the ants which are attracted by the sweets are too zealously occupied with getting the nectar to pay any attention to the other insects—many of them directly harmful—similarly occupied—and incidentally introducing various injurious fungi and making the entrance of plant-lice, etc., easier. "With the increase in the amount of nectar secreted, and the consequent increase in the attractiveness of the plant for all kinds of animals, the injury from which the plant suffers increases; and when because of the entrance of fungi or through some other cause the secretion is restricted, the plant suffers less than normally!"

New observations on Schimper's typically myrmekophilous plant *Humboldtia laurifolia* (Fig. 2) were made in Ceylon last year by the well-known myrmecologist and explorer Karl Escherich. This plant has hollow internodes with an opening to the exterior near the upper end of each; there are numerous nectaries on the stipules and leaves, and the hollows are frequently occupied by ants. The presence of the attracting nectaries, the suitableness of the hollows for ant homes, and the fact that ants are frequently destructive to plant lice and other insects, seem here to make an admirable combination in support of Schimper's theory. Escherich found, however, that

1. Only from twenty to fifty per cent of the hollows in the plants contain ants—and where there were no ants, there was not the opening to the exterior. In other words, these openings are not natural invitations to the ants to come in and make themselves at home, as had been supposed, but are made by the ants themselves.

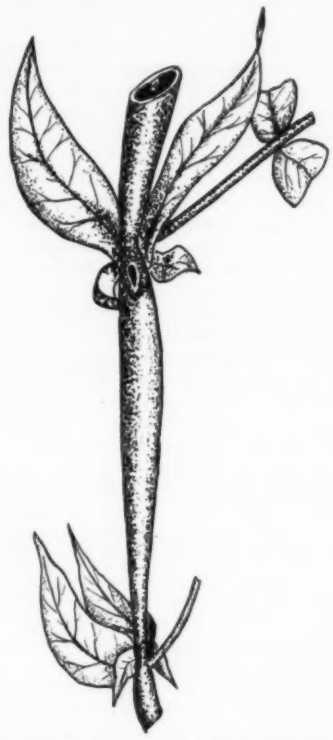

Fig. 2.—*Humboldtia Laurifolia* Showing Entrance to Swollen Hollow of Stem. After Schimper.

2. The Humboldtia is occupied by several species of ants, at least some of which form their nests outside of the tree as well as within it. Among the species are members of the genera *Technomyrmex*, *Tapinoma*, *Monomorium*, *Cremastogaster* and others.

3. The ants taken from these trees were "nothing less than aggressive." On the contrary, they were so meek that even on violent shaking the trees they never came out to fight the enemy, but remained quietly in their safe dwellings.

4. Many of the branches in every plant (in some cases all of the occupied branches) occupied by ants showed the effects of various injuries, some the results of wood-peckers.

From these observations it again appears that the ants are not only of no protective value to the Humboldtia, but through attracting wood-peckers actually bring injury to the host. The relation, instead of being mutualistic, is parasitic.

All of the critical observations made in recent years are by myrmecologists, and all lead to the same conclusions. As Escherich says, the ant-protection theory "never would have reached its power if myrmecologists had from the start made the necessary observations;

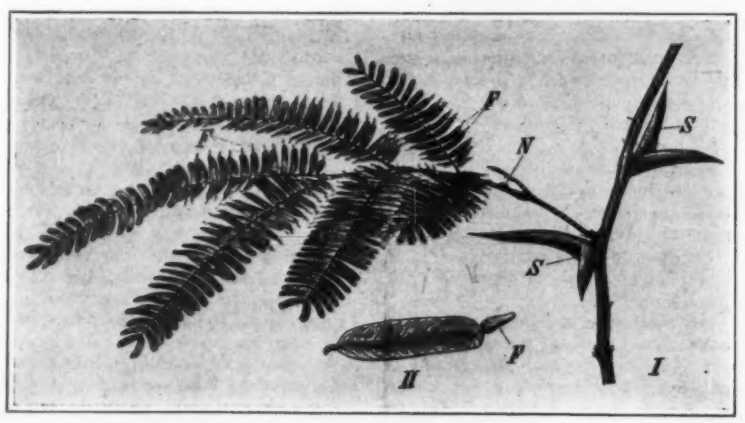

Fig. 3.—Twig of Acacia, Showing Hollow Thorns With Openings Made by Ants. An Enlarged Leaflet Shows the Fatty Body Used by the Ants as Food.

for every ant student knows how adaptible the ants are, and how they are able to discover every hollow and to turn it to their own uses. He also knows how ants differ among themselves as to their aggressiveness, and that some are good-natured and not at all adapted to keeping off harmful insects." On the other hand, the botanist sees in every ant a fighting animal that

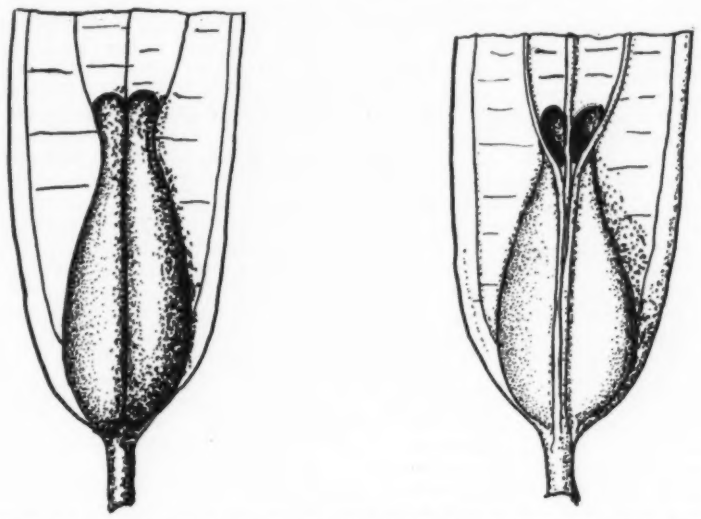

Fig. 4.—Lower Half of Leaf of *Tococa lancifolia*, Showing the Pockets in Which the Ants Build Nests. After Schumann.

will not tolerate another insect within its reach, and that is feared by all other insects.

So many of the peculiar plant structures for which the botanist has been unable to find a satisfactory physiological explanation fit in very well with the ant-protection theory; and it is therefore no wonder that in the enthusiasm of its first formulation it should be extended to many cases in which the facts had not been fully gathered. "The aptness of the assumptions was indeed considered as to a degree a confirmation of the premises."

It is now known that at least in very many cases these assumptions are untenable. It is of course impossible to say that the whole theory is worthless; that would be going along the same path, namely, generalizing from insufficient data. It seems that in some cases, for example, *Centaurea alpina*, the extra-floral nectaries do actually serve the plants in the sense of the ant-protection theory.

As illustrative of exceptions to another widely-accepted generalization about mutualism between plants and animals, we may refer to those cases in which insects that are supposed normally to serve plants from which they get nectar, by pollinating the flowers, get their nectar by biting through the flower from the outside. Such instances have been frequently noted; only recently some nasturtiums (*Tropœolum*) were observed while a bumble-bee flew from one flower to the next, cutting through the spur and extracting the nectar, without coming near the stamens or stigmas. In this case the insect was getting all the benefit and the plant was getting nothing. While the removal of the nectar is in such cases no serious loss to the plant, the relationship is nevertheless not a mutual one. Indeed, we should expect that in the relations between insects and flowers the insects would in many cases come out ahead. There are many plants whose flowers are so constructed that they fit in very well with the theory of adaptation to insect visits for purposes of pollination, but which do not at all depend upon the insects to secure pollination. Examples of these are the sweet-pea, in which normally self-fertilization takes place; and the hawk-weed (*Hieracium*) in [illegible] least of the flowers produce seeds parthenogenetically—that is, without fertilization.

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There are many associations between fungi and higher plants to which a similar mutualism has been attributed, the exchange of services being supposed to concern chiefly the nutrition of the two partners. The presence of fungi in the roots and other underground portions of plants has long been known. At first these fungi were regarded as parasites. In 1881 Kamienski pointed out that the fungus in Monotropa (*M. Hypopitys*, a plant without chlorophyl related to the "Indian pipe" of our woods) is probably not a parasite, since there is no evidence of injury to the plant; and he advanced the view that the Monotropa furnishes the fungus a convenient medium or substratum and that in return the fungus absorbs for the other plant its nutriments from the soil or humus. Kamienski spoke of this as a most striking case of mutualism among plants. (Fig. 5.)

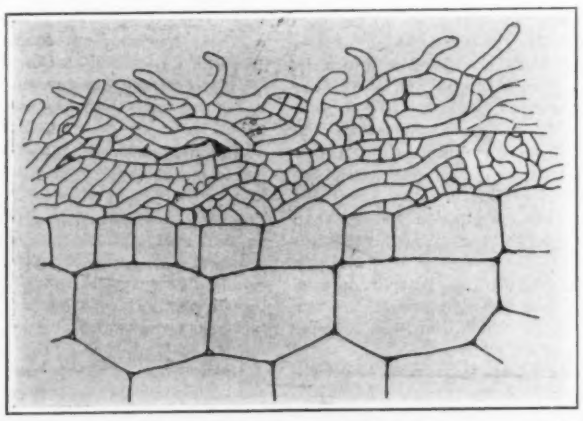


Fig. 5.—Microscopic View of a Piece of Monotropa, Showing Fungus on Surface of Root. After Kamienski.

But the mutualism is here rather one-sided. The presence of the fungus in the root of Monotropa does no harm to the latter, but is of advantage to the fungus. On the other hand, the fungus absorbs for Monotropa, at no expense to itself. In other words, the fungus replaces the root-hairs of the other plant, to its own great advantage. But as there is no advantage to Monotropa, which can get along very well, according to Kamienski's hypothesis, without the fungus, the mutualism is not obvious—unless one considers it an advantage to a plant to be inhabited by a fungus without receiving any harm.

The same botanist also suggested that there is mutualism between the root fungus and the beech tree, and also the cone-bearing trees. After the nature of the root-tubercles on the plants of the bean-family had been worked out, the relationship between the bacteria causing the nodules and the plants upon which they were formed was also classed as "symbiotic" or mutually advantageous. In these cases it is pretty well established through experiments that the leguminous plant supplies carbonaceous food to the bacteria, and that these assimilate atmospheric nitrogen, making this available to the partner. The idea of mutualism was extended to include nearly every case of association between a fungus and a higher plant that did not show evidence of serious injury to the higher plant.

In recent years, however, there has been a reaction against accepting this theory without better evidence. By means of experimentation it has been found that in many of the plants that bear root-fungi, all the processes can proceed quite normally even in the absence of the fungus. In such cases, of which Gallaud has gathered a large number, the relationship is one of harmless parasitism. That is, the fungus gets from its host all or most of its food without doing the host enough harm to kill it or sicken it. The host has in such cases no advantage whatever from the presence of the fungus; on the contrary, it is deprived of all the stored food which goes to feed the fungus. The advantage is all with the fungus.

It is a well-known fact that our common green plants depend upon their chlorophyll (the green pigment of leaves, young stems, etc.) for the ability to make sugars and starches out of simpler raw materials obtained from water and air. Mushrooms, molds, puff-balls, etc., can absorb the organic food which they need from the humus or organic debris on the forest floor. Seed plants without chlorophyll, like our "Indian pipe," the pine-sap, coral-root orchid and others, are comparatively rare, and have always been considered as anomalous with respect to their nutrition. Practically all of these plants that have been examined have been found to harbor some kind of fungus within or upon the roots. The assumption of mutualism in such cases has furnished such a simple explanation of the relationship that this assumption has been for long accepted by many without question. But it remains nothing but an assumption.

For in the first place, Monotropa has been found growing without the fungal partner by the Bohemian botanist Jaroslav Peklo. So far as getting organic food is concerned, the presence of the fungus is not necessary in this plant. And other non-chlorophyllous seed-plants have also been found without the fungus.

In the second place, experiments made in laboratories show that very many of the higher plants are quite capable of absorbing organic food directly. This includes a large number of common green plants that ordinarily manufacture their food with the aid of chlorophyll.

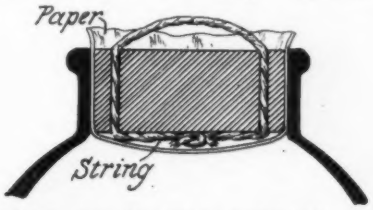
In the third place, a number of the fungi that form these partnerships with higher plants have been cultivated without their partners, and have demonstrated that they are well able to live by themselves.

And so on the positive side as well as on the negative, the assumption of the dependence of these plants upon the fungi turns out to be unwarranted. Even in the case of lichens it has been questioned whether the relation is beneficial to the algal partner, since a number of the algæ commonly found in lichens have been grown without the assistance of the fungus. While it may be true that in certain special cases there is an exchange of materials or of other advantages, it is not necessary to assume that this relation of mutual benefit obtains in all such associations. Thus another beautiful theory is called upon to revise itself.

With the rapid development of our knowledge about heredity, variation, selection and other problems in organic evolution, it should not be difficult for us to give up long-cherished theories when these are seriously attacked. We do not need to-day to hold fast to the idea that whatever we find in the living world is an indication of fitness or adaptation. On the one hand, the theological idea of *purpose* in creation does not call for the scientist's support. And on the other hand, we know that characters can survive without being "fittest." If a structure or a habit is one that does not lead to the extermination of its possessor, it may be indifferent, or even harmful. So we find relationships and associations between organisms able to persist indefinitely without being of distinct advantage to both partners. Instead of illustrating, as has been supposed, the "survival of the fittest," they simply illustrate what may be called the "persistence of the unfatal."

A Simple and Clean Closure for Stock-bottles

THE main stock of various solid chemicals is usually kept in the cork stoppered bottles in which such materials are supplied by the manufacturers. This is the cause of considerable inconvenience, as the cork is apt to suffer after having been pried off a number of times, and fragments of cork can hardly be prevented from



falling down into the bottle, contaminating its contents. To prevent this, H. Kohl in the *Chemiker Zeitung* recommends the following expedient: Two holes are bored in the cork and a piece of string is passed through, its ends being tied together, as shown in the illustration. The cork is then covered with a piece of paper in order to prevent cork or paraffin from falling into the bottle.

Scientific Progress and Prospects*

The Peaceful Arts More Mighty Than the Exploits of War

By A. A. Campbell Swinton

ALL advance in the relations between man and nature whereby man gains to any greater extent the mastery may be described as scientific progress; and in this connection we must recognize that many things which we now look upon, and have for ages regarded as entirely commonplace, were, at the time of their inception, really very remarkable indeed. Take, for instance, the application to human needs of fire. Animals, even of the highest types, make no use of it. There must have been a period when man also did not understand its properties, and, like the animals from which he has sprung, was afraid of it and left it severely alone. A time must next have come, and with that time the valorous man who first had the temerity to experiment with this very powerful and destructive agent.

Think of this prehistoric investigator into the means and effects of combustion in that far distant age; consider his inferior mental equipment; imagine his savage surroundings; take into account, also, his lack of any but the most primitive appliances. Must we not laud his enterprise and admire his courage? Must we not also acknowledge the enormous advantages his investigations have gained for all his posterity? The warming of their bodies and the cooking of both animal and vegetable nutriment would, no doubt, be the first uses to which our remote ancestors would apply the new agent; but soon would follow the firing of pottery, up to that date merely sun-baked, then the reduction and smelting of metals, and finally the whole galaxy of the arts. What is scientific progress if this is not? And yet it leaves off where what we usually mean by science begins, namely, about the Græco-Roman period. Look out, however, into London to-day, and recognize how little of all we see around us could have ever existed but for those early high-temperature experiments made so many thousands of years ago. Without them, could human beings even live in this northern climate?

Here may I point out that, curiously enough, it is only when we go back to the earliest evidences of primitive human life upon this planet that we take the true philosophical course of naming the periods we are dealing with after the main material advances in scientific progress made during those periods by the human race. We talk of the Stone age, of the Bronze age, or the Iron age, to denote those vast expanses of time during which the primitive inventor was discovering the means of applying new materials to what was then the great necessity of mankind, namely, weapons for the chase, for self-protection, and for war upon his enemies.

Later in history we find that this really philosophical method is abandoned. As we come to know more as regards the position, supremacy, and conditions of particular races, and still further when we become better acquainted with the deeds and achievements of particular individuals, we find that historians have a tendency to overlook the enormous influence of the results obtained by scientific investigators and discoverers, and to make it appear as though the current of events were really governed by those who, from accident of birth, official position, political influence, or martial achievements, have made for themselves reputations as leaders of men.

To see that this view is wrong we have only to survey the past. Can it for an instant be doubted that the labors of the unknown prehistoric individual to whom I have just alluded, who first discovered the properties of fire, or of those who originated the smelting of metals, who launched their frail, and at that time novel, coracles upon the ocean, and first applied wheels to the primitive cart, are more living factors to-day than the valor of all the warriors, the wisdom of all the statesmen, or the wiles of all the politicians that the world has seen? It is a truism, indeed, that the world knows little of its greatest men.

Can it be questioned that the discoveries of Archimedes and his disciples have more effect to-day than the battles of Alexander or of Hannibal? Or, if we turn to modern times, can it be gainsaid that Watt and Stephenson, Davy and Faraday, have done more to change both the course of history and the material conditions of life than did Napoleon or Wellington, Walpole or Pitt?

The fact is, as I once remember hearing lamented by no less a statesman than the late Lord Salisbury, that while the work of the politician, the statesman, the soldier, or the leader of men, however great and however fortunate, is of necessity but transitory, what is accomplished by one man being undone by another—the work of the scientific discoverer and inventor is everlasting. However insignificant this work may apparently be, provided it is new it adds something more to that great store of human knowledge and experience which is slowly accumulating, and enables man more and more to triumph over nature. Moreover, results that appear of but slender importance at the time of their discovery often turn out in the end to be of the greatest moment.

For the undue amount of influence on the progress of the world that is attributed to leaders of men, in comparison with that exerted by investigators of nature, historians are no doubt to blame. In stating this, however, one must in justice remember that, after all, most histories are written to sell, or, if not that, to bring fame to their authors. Further, we must allow that the story of scientific investigation is frequently not very interesting, at any rate to the general public, who may justly find such a story dull as compared with accounts of the stirring episodes that occur in the Senate or the feuds that are settled on the battlefield. Thus the tale of, say, Marlborough's campaigns makes probably more picturesque reading, and is more likely to interest the average student, than would be a history of the patient scientific work that led up, about the same period, to the enunciation, say, of Boyle's law of the expansion of gases. We can admit this, though there can be no doubt that the permanent influence of Boyle's discovery on the history of the world has been in the past, and will continue to be in still greater ratio in the future, incomparably greater than was that of all the battles of the day, inasmuch as Boyle's law was an important link in the chain of discoveries that led up to the steam engine and modern industrial development; while to-day the effects of the wars of the seventeenth century have, for all practical purposes, passed away.

The fact is that there is a glamor attached to the position of those who are supposed to direct the history of nations that prevents the real directing forces from being seen in their true proportions. The great statesmen, the great generals, leaders of mankind in general, are, after all, nothing much more than glorified policemen, whose utility to the world is only occasioned by the imperfections of human nature. As organizers they are no doubt useful, but they generally benefit particular nations at the expense of others; and, as a rule, they leave little behind them that will stand the test of centuries.

Another product of human endeavor which also seems to have an undue amount of importance attached to it in regard to its influence on human progress is literature, which I am here considering apart entirely from its æsthetic claims upon us as a means of relaxation. That literature has a directive influence, and that a powerful one, no one can deny; but I fancy that all scientific men will agree that it is not to be compared with that exercised by material discoveries and inventions. In saying this, I know that it is the fashion to ascribe the beginning of all modern science to what is contained in the "Novum Organum;" but I rather fancy that if we could truly estimate the influence on the world's history of the two men, we should find that Roger Bacon, the inventor of gunpowder, would come before the better known Francis Bacon, who, some centuries later, wrote his great work on the new learning. Indeed, probably the chief merit of the "Novum Organum" was that it assisted a return to experimental methods as opposed to what had become the benumbing system of Aristotle, who, by the way, is interesting to this society for the reason that he was the author of the immortal, if not very illuminating, phrase that "nature abhors a vacuum." Anyway, since the earliest times there has never been a better organized and more successful mutual admiration society than that formed by the writers of the world, who have always been chiefly concerned to discuss one another and one another's scripts. This, and the fact that the written word endures, has given to the wielders of the pen a prominence in history to which they are scarcely entitled by their influence on progress.

At the present time, when it is the fashion to ascribe the production of all wealth to the manual laborer and all progress to the politician, it is more than ever necessary that correct views should be insisted on. Let us, therefore, emphasize the fact that from the beginning of the world all advance has been due, not to the many, but to a few exceptional individuals; and had it not been for the genius of these we should still be naked savages, not even painted with the proverbial woad.

As an instance, take the electric telegraph, which has had more effect on civilization than almost anything else during the past century, and gives employment to thousands. The names of those to whom it is due, beginning with Franklin, Volta, and Galvani, going on with Morse and Cook, and ending with, say, Wheatstone and Kelvin, can literally be counted upon one's fingers. Nor is it very different with the steam engine or with the railway itself, which, to read some of the newspapers to-day, one would almost think had been invented by the rank and file of the railway workers.

Most really scientific workers feel that knowledge for knowledge's sake is a sufficiently worthy object for pursuit, and are content with the extension of knowledge and the satisfaction that it brings without immediately desiring precise information as to the practical results that are likely to follow from any particular line of investigation. It is well that this is so, as otherwise many of the lines of scientific research that have been most fruitful in bringing lasting benefits to mankind would never have been begun or followed up.

As an instance of this, could there be a better example than the history of that most remarkable and important discovery in physics which was the primary cause of the foundation of this society?

Consider for a moment the position of affairs many years ago, when Sir William Crookes first commenced his laborious experiments on the electric discharge through rarefied gases. Could anything be imagined of more purely academic interest, and, at the time, seemingly less likely to lead to results of a practical nature? The small scale, the extreme delicacy of the apparatus, the uncertainty of the results, the minuteness of the forces involved, all tended to give to the investigations an air so entirely aloof from the practical concerns of everyday life that one can scarcely wonder that for years it was only a few of the very foremost scientific intellects who had sufficient insight to take much interest in the matter.

Yet we all know how things have turned out; how, as a direct result from these very recondite investigations, we have had the discovery of the Röntgen rays, with their practical applications to the investigation of the human frame, to the relief of suffering, and to the cure of disease; and also, as another result, perhaps the most momentous and far-reaching upheaval in scientific thought on the constitution of matter and the nature of electricity, that has taken place for centuries, heralding the birth of a new idea, that of radio-activity, which may in future be destined to prove the salvation of the whole human race from annihilation. Here, of course, I refer to the vast and previously unsuspected source of energy that modern investigations have shown to lie hidden away in the atoms of matter, a store which is revealed by the energy given out by radium and other radio-active substances, and one which we may hope to see made available for human use in centuries to come, when others, such as those contained in the coal and oil of the earth, at present being exploited, are exhausted.

So far as I am aware, the results of modern discovery have had no effect in weakening our belief in the truth of the great principle of the conservation of energy as defined in what is commonly called the first law of thermodynamics, which law is really a statement that the sum of energy in the universe, just as the amount of matter, is a constant, and cannot be either increased or diminished by any means whatever.

When, however, we come to the so-called second law, which, as stated by Clausius, is that it is impossible for a self-acting machine, unaided by external agency, to convey heat from one body to another at a higher temperature, or, as given by Lord Kelvin in a somewhat different form, that it is impossible by means of inanimate material agency to derive mechanical effect from any portion of matter by cooling it below the temperature of the coldest of the surrounding objects, we find that even the authors of these statements are prepared to admit that this second law stands on a totally different basis from the first law, and, as declared by Maxwell, can only be said to be statistically correct, or correct only when we are dealing with masses of matter and not with individual molecules.

Indeed, it was in this connection that Maxwell propounded his celebrated proposition, in which he supposes that a demon who could see individual molecules, and was possessed of superhuman dexterity, could open and close an aperture in a partition dividing a vessel into two separate portions, A and B, so as to allow only the swifter molecules to pass from A to B, and only the slower ones from B to A, in which case, without the expenditure of work, the temperature of B would be raised and that of A lowered, in contradiction to this second law.

* From the presidential address delivered to the Röntgen Society and published in *Nature*.

It will further be observed that in the definitions quoted above Clausius is careful to qualify his statement by words to the effect that there must be no external aid, while Lord Kelvin is even still more specific, and expressly limits the whole law to things inanimate.

Now lately, in London, we have had—I suppose as the result of Prof. Bergson's remarkable writings—one of the usual periodic outbreaks of more or less metaphysical discussion, and, incidentally, there has been raised quite seriously the question as to whether living organisms are subject to these laws of thermodynamics or not.

So far as the first law is concerned, there seems to be complete agreement that there can be no question of any but an affirmative reply, as we can scarcely suppose living things to be capable of creating energy any more than of creating matter.

But when we come to the second law there are apparently those who hold that it is different—who, in fact, believe that there is good reason for doubting whether this second law, which prevents us by the use of any mere machine from getting mechanical effect from the general stock of heat, applies to living organisms at all. Indeed, on the contrary, it is contended that it is probable that, in the case of certain animate bodies, this is actually being accomplished all the time; in other words, that there exist living things which in some fashion or other do very much what was the business of Maxwell's demons to do, and in this manner extract the energy that they require from the general stock. Here, obviously, is a most important matter for investigation, and one, having regard to its combined physiological and physical aspects, peculiarly adapted to be tackled by the members of the Röntgen Society, that is to say, if those who put it forward can make out a sufficient case to make actual experiment worth while.

The interest of the question will be especially apparent to anyone who has seen the so-called Brownian movements which can be perceived by ultramicroscopic methods in finely divided solid matter, such as particles of colloidal gold suspended in a liquid or of tobacco smoke in a gas. These movements are now believed to be due to the actual jostling of the minute particles by the moving molecules themselves, and give the most wonderful notion of the ceaseless state of agitation that exists among the molecules of all substances at any temperature above that of the ultimate zero, and the vast amount of energy that is stored in these perpetual movements.

Indeed, so remarkable do the Brownian movements appear that their original discoverer, who detected them in finely divided vegetable matter, came to the conclusion that the particles were alive.

To return to the main question, however, without presuming to pronounce any opinion one way or another on the very startling idea that living matter is not always subject to the second law of thermodynamics, but finds means, in some cases at all events, to evade its provision, I desire to direct attention to the stupendous consequences that would follow could such a view be established. Here, at last, we should have the equivalent of the perpetually burning lamp of the story books, which consumed no oil; the perpetual fire of the burning bush, which required no fuel. We should have immediately to hand the means of producing the perpetual motion dreamed of by mediæval philosophers. We should only have to cultivate the right kind of organisms in sufficient masses, and they would do all this for us. Moreover, there would be nothing lost; the heat that was thus accumulated locally for our needs would dissipate itself again into the common store, as would also the mechanical effects after they had done their work. The unordered molecular motions of which the Brownian movements give us an indication—motions which constitute heat—would merely be directed for a time in the particular manner needful to give us the power that we require. Life would be the directing force; but it would be a directing force only, and would do no work.

It is a fascinating prospect, giving us a glimpse of what some may perhaps think is destined to take the place of fuel a few hundred years hence, when the latter is all exhausted and before means have been found to unlock the still greater stores of atomic energy that have already been alluded to. To those, however, who have been brought up to rely on the orthodox doctrines of thermodynamics, it seems not only very revolutionary, but also very heterodox from a physical point of view. Personally, as one totally ignorant of biology, I am only here concerned to point out the inevitable consequence of admitting that living matter is not subject to the second thermodynamic law, a proposition which I venture to believe has never before now been put forward seriously in any responsible quarters.

Among the many scientific problems that await solution, problems which, if satisfactorily solved, would have an enormous effect on the habits of mankind, is that of distant electric vision, or the power to see objects a great way off by electrical means; in other words, to do for the sense of sight what the telephone has done for the sense of hearing. Indeed, if this extension of our sense of vision was obtained, we could well afford to dispense with any extension of our other senses, namely, those of taste, smell, and touch, the senses of sight and of hearing being, for all ordinary purposes, much more important to us than are the others.

So long ago as the year 1908, in connection with a paper published in *Nature* by the late Mr. Shelford Bidwell, I wrote a letter in that journal suggesting that the difficulty of obtaining the necessary enormous numbers of synchronized operations per second could possibly be solved by the employment of two beams of kathode rays, one at the transmitting and one at the receiving station, sychronously deflected by the varying fields of two electromagnets placed at right angles to one another and energized by two alternating electric currents of widely different frequencies, so that the moving extremities of the two beams would be caused to sweep synchronously over the whole of the required surfaces within the one-tenth of a second necessary to take advantage of visual persistence; and that, so far as the receiving apparatus was concerned, the moving kathode beam would only have to be arranged to impinge on a sufficiently sensitive fluorescent screen, and, given suitable variations in its intensity, to obtain the desired result. As, since that date, I have several times been asked to explain more in detail this idea, I now propose to do so, though it must be distinctly understood that my plan is an idea only, and that the apparatus has never been constructed. Furthermore, I would explain that I do not for a moment suppose it could be got to work without a great deal of experiment, and probably much modification. It is, indeed, only an effort of my imagination, and can be useful merely as a suggestion of a direction in which experiment might possibly secure what is wanted. What, however, is claimed is that, so far as I am aware, it is the first suggested solution of the problem of distant electric vision in which the difficulty of securing the required extreme rapidity and accuracy of motion of the parts is got over by employing for these parts things of the extreme tenuity and weightlessness of kathode rays. Indeed, apart from the revolving armatures of the alternators employed for synchronization, which present no difficulty, there is no more material moving part in the suggested apparatus than these almost immaterial streams of negative electrons. Furthermore, as will be seen, only four wires, or three wires and earth connections at each end, are required.

In the diagrammatic illustration the transmitter is shown on the left-hand side and the receiver on the right-hand side. The transmitter consists of a Crookes tube *A* fitted with a kathode *B*, which sends a kathode-ray discharge through a small aperture in the anode *C*, the kathode rays being produced by a battery or other source of continuous electric current giving some 100,000 volts. *D* and *E* are two electromagnets placed at right angles to one another, which, when energized by alternating current, will deflect the kathode rays in a vertical and in a horizontal direction respectively.

The receiving apparatus consists similarly of a Crookes tube *A′* fitted with a kathode *B′*, which, in circumstances to be further described, transmits kathode rays through an aperture in the anode *C′*. *D′* and *E′* are two electromagnets placed at right angles, similar to those in the transmitter, the two magnets *D* and *D′*, which control the vertical motions of the kathode-ray beam, being energized from the same alternating dynamo *F*, which has a frequency, say, of ten complete alternations per second; while the other two magnets *E* and *E′*, which control the horizontal movements of the kathode-ray beam, are energized by a second alternating dynamo *G* having a frequency of, say, 1,000 complete alternations per second.

In the receiver *H* is a fluorescent screen, upon which, under conditions to be further described, the kathode rays impinge, and the whole surface of which they search out every tenth of a second under the combined deflecting influence of the two magnets *D′* and *E′*, with the result that under these conditions the screen fluoresces with what appears to the eye as a uniform brilliancy.

Similarly, in the transmitting apparatus, the kathode rays fall on a screen *J*, the whole surface of which they search out every tenth of a second under the influence of the magnets *D* and *E*. Further, it is to be remarked that as the two magnets *D* and *D′* and the two magnets *E* and *E′* are energized by the same currents, the movements of the two beams of kathode rays will be exactly synchronous, and the kathode rays will always fall on the two screens *H* and *J* on each corresponding spot simultaneously.

In the transmitter the screen *J*, which is gas-tight, is formed of a number of small metallic cubes insulated from one another, but presenting a clean metallic surface to the kathode rays on the one side, and to a suitable gas or vapor, say sodium vapor, on the other. The metallic cubes which compose *J* are made of some metal, such as rubidium, which is strongly active photoelectrically in readily discharging negative electricity under the influence of light, while the receptacle *K* is filled with a gas or vapor, such as sodium vapor, which conducts negative electricity more readily under the influence of light than in the dark.

Parallel to the screen *J* is another screen of metallic gauze *L*, and the image to be transmitted of the object *N* is projected by the lens *M* through the gauze screen *L* on to the screen *J* through the vapor contained in *K*. The gauze screen *L* of the transmitter is connected through the line wire to a metallic plate *O* in the receiver, past which the kathode rays have to pass. There is, further, a diaphragm *P* fitted with an aperture in such a position as, having regard to the inclined position of *B′*, to cut off the kathode rays coming from the latter and prevent them from reaching the screen *H* unless they are slightly repelled from the plate *O*, when they are able to pass through the aperture.

The whole apparatus is designed to function as follows:

Assume a uniform beam of kathode rays to be passing in the Crookes tubes *A* and *A′*, and the magnets *D* and *E* and *D′* and *E′* to be energized with alternating current, as mentioned. Assume, further, that the image which it is desired to transmit is strongly projected through the lens *M* through the gauze screen *L* on to the screen *J*. Then, as the kathode rays in *A* oscillate and search out the surface of *J*, they will impart a negative charge in turn to all the metallic cubes of which *J* is composed. In the case of cubes on which no light is projected, nothing further will happen, the charge dissipating itself in the tube; but in the case of such of those cubes as are brightly illuminated by the projected image, the negative charge imparted to them by the kathode rays will pass away through the ionized gas along the line of the illuminating beam of light until it reaches the screen *L*, whence the charge will travel by means of the line wire to the plate *O* of the receiver. This plate will thereby be charged; will slightly repel the kathode rays in the receiver; will enable these rays to pass through the diaphragm *P*, and, impinging on the fluorescent screen *H*, will make a spot of light. This will occur in the case of each metallic cube of the screen *J*, which is illuminated, while each bright spot on the screen *H* will have relatively

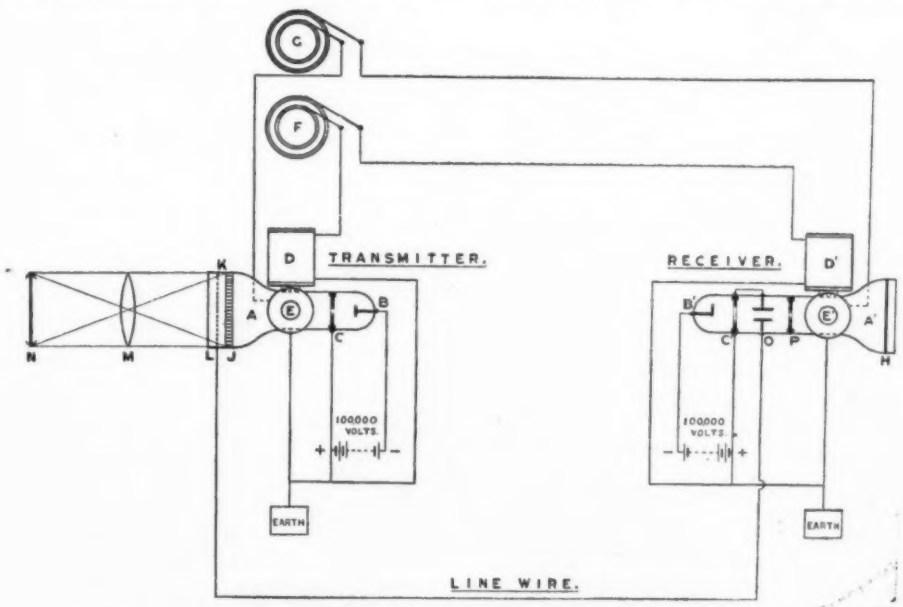


Diagram Proposed for Distant Vision by Electricity.

exactly the same position as that of the illuminated cube of *J*. Consequently, as the kathode-ray beam in the transmitter passes over in turn each of the metallic cubes of the screen *J*, it will indicate by a corresponding bright spot on *H* whether the cube in *J* is or is not illuminated, with the result that *H*, within one-tenth of a second, will be covered with a number of luminous spots exactly corresponding to the luminous image thrown on *J* by the lens *M*, to the extent that this image can be reconstructed in a mosaic fashion. By making the beams of kathode rays very thin, by employing a very large number of very small metallic cubes in the screen *J*, and by employing a very high rate of alternation in the dynamo *G*, it is obvious that the luminous spots on *H* by which the image is constituted can be made very small and numerous, with the result that the more these conditions are observed the more distinct and accurate will be the received image.

Furthermore, it is obvious that, by employing for the fluorescent material on the screen *H* something that has some degree of persistency in its fluorescence, it will be possible to reduce the rate at which the synchronized motions and impulses need take place, though this will only be attained at the expense of being able to follow rapid movements in the image that is being transmitted.

It is further to be noted that as each of the metallic cubes in the screen *J* acts as an independent photoelectric cell, and is only called upon to act once in a tenth of a second, the arrangement has obvious advantages over other arrangements that have been suggested, in which a single photoelectric cell is called upon to produce the many thousands of separate impulses that are required to be transmitted through the line wire per second, a condition which no known form of photoelectric cell will admit of.

Again, it may be pointed out that sluggishness on the part of the metallic cubes in *J* or of the vapor in *K*, in acting photoelectrically, in no wise interferes with the correct transmission and reproduction of the image, provided all portions of the image are at rest; and it is only to the extent that portions of the image may be in motion that such sluggishness can have any prejudicial effect. In fact, sluggishness will only cause changes in the image to appear gradually instead of instantaneously.

Many modifications are, of course, possible in detail. For instance, the plate *O* of the receiver might perhaps better be replaced by an electromagnet or solenoid so arranged as to repel the kathode beam when energized. Again, the somewhat crude form of photoelectric cell described, composed merely of insulated cubes of rubidium in contact with sodium vapor, might be improved upon. Indeed, it is highly probable that research will reveal much more sensitive materials, the use of which would vastly improve this part of the apparatus, which at present is probably the one least likely to give the desired results.

The Present Status of Wireless Telegraphy.—In a lecture recently delivered at Berlin, Count G. von Arco, after outlining the general working of the main parts of radio-telegraphic installation, began their detailed discussion with the consideration of the antenna problem. Vertical antennas which until quite recently were those most generally in use, are carried by huge masts which must assume enormous dimensions whenever long distances are to be spanned. In fact, the problem of long-range radio-telegraphy has long been dependent almost exclusively on the design of antennas. Whether electric waves are transmitted through the air, the earth or both media simultaneously was until recently an open question, though there was strong evidence in favor of the earth transmission theory. However, the systematic work done by Dr. Kiebitz at the instigation of the German Postal Department has now shown the earth as such to be capable of transmitting electric energy to considerable distances, while sufficient receiving energy, even at the greatest distances, may be derived from the earth alone. The Telefunken Company, on the strength of these exeriments, has designed many types of earth antennas exerting well directed effects and apparently preferable in other respects to aerial antennas. The system becomes much more independent of disturbance due to atmospheric discharges and to the interference of other stations. For the rest the electrical behavior of earth antennas is very similar to that of aerial antennas. As regards, next, the modern system of musical "damped" sparks, this has been further improved upon, and the new apparatus, though of simple design, allows the pitch of the sound to be readily altered. The Nauen Experimental Station (near Berlin), which equalled in power and range the two largest Marconi stations (viz., those connecting England with Canada) has recently been raised to an output four times the initial figure. The height of the tower (originally 330 feet) has been doubled, and two new engines and apparatus halls have been fitted up.

Science Notes

Homogenized Milk.—In an article on colloids, published in *Zeitschrift für angewandte Chemie*, Dr. H. Freimann mentions an interesting example of the production of a colloidal solution by mechanical means. By forcibly projecting milk against a hard polished surface, for instance, of agate, the little fat globules are very completely atomized into colloidal particles, so small that they can hardly be distinguished under a microscope. As a result of this, milk so treated does not separate off a layer of cream on standing, and cannot be skimmed.

Brussels Institute of General Biology.—An international institute of plasmogenesis and general biology has been founded at Brussels by Dr. J. Felix and Prof. Guinet. The aim of the institution is to study the problems of synthetic biology and kindred fields as brought out by the late work of Harting, Quincke, Leduc, Dubois and others. Before long the institute will be open to all workers who present a plan of research which appears to be of interest to the committee. It is intended to publish an international bulletin regarding the researches of the Institute as well as all other work in this field.

Instinct and Intelligence.—In a lecture delivered before the Royal Institution recently, Dr. Chalmers-Mitchell incidentally referred to the distinction between instinct and intelligence. He illustrated the case in point by reference to a snake, about four feet long, which he showed the audience, with the statement that this snake had been presented to a young monkey and a bird, which showed fright at the snake, though as a matter of fact it belonged to a harmless species, and they had never seen a snake before. Such fear must therefore be the result of instinct and not in any sense of acquired experience or reasoning. However, other animals to whom the same snake was shown displayed no kind of concern. Human beings, said Mr. Mitchell, like to suppose that other animals act by instinct, while man is guided by intelligence. The truth, however, is that as far as the higher animals are concerned, it is impossible to draw any exact line between instinct and intelligence.

Prolonged Life of Tissues Outside of Organism.—Some years ago Dr. Alexis Carrel, of the Rockefeller Institute, showed that the various organs and tissues dissected out of the organism can be maintained in a living state for a more or less prolonged time by placing them in a suitable medium at the right temperature, and that such tissues may even grow for several days. His results have been contradicted by other authors, but more recently Dr. Carrel has achieved even more striking results. By taking the preparations out of their nutritive medium at the right time and transferring them to another medium, consisting of three parts of the normal plasma of the animal in question and two parts of water, and repeating the operation at proper intervals up to as many as nine times, he finds that the connective tissue shows great activity even as long as thirty-four days after its excision from the body.—*Cosmos.*

The Inflammability of Celluloid.—It is well known that celluloid is highly inflammable and on various occasions has caused loss of life and property. The chemical process of its combustion has recently been studied by Dr. Panzer of Vienna, and the results of his experiments are of great value to science and industry, as they show a way of dealing with a celluloid blaze. This substance does not ignite spontaneously; but it was found that after extinguishing the flames of a piece of burning celluloid, decomposition would still go on, and would continue even in a vessel filled with carbonic acid or steam. This shows that atmospheric oxygen is not necessary for decomposition; that a fire caused by celluloid can only with difficulty be put out with water, and that ordinary chemical fire extinguishers are useless. The flameless combustion starts at a temperature of but little over 100 deg. Cent. (212 deg. Fahr.) so that the decomposition may be started by a flame situated quite some distance away. The white vapors resulting from the combustion form an explosive mixture with air. To extinguish a celluloid blaze in a building is a most difficult task, if not impossible. On account of the rapidly spreading flames and the excessive heat of the fumes (nearly 750 deg. Fahr.) the sent of the blaze is almost inaccessible to the fire fighters. Ignition and gasification of celluloid may be caused by an open flame or simply by heat. The temperature required for decomposition lies between 105 to 185 deg. Cent. (221 to 365 deg. Fahr.), therefore a hot stove can cause the decomposition. If a piece of celluloid is slowly heated, it may be observed that it softens at first, then blisters begin to appear all over and suddenly decomposition sets in, sometimes accompanied by flames. The products of dissociation consist of gases, liquids and carbonaceous matter. The colorless gases contain carbon monoxide and nitrogen oxides and are therefore extremely poisonous.—*Chemiker Zeitung.*

Trade Notes

A Gray Tint for Brass.—Take 20 parts of tartar emetic and add just enough hydrocloric acid to dissolve; then dilute with half the total volume of water. Apply to the brass.—*Neueste Erfind u. Erfahr.*

Cleaning Playing Cards.—Dip a piece of cotton cloth in petroleum and rub carefully over the card; finish with a piece of dry cloth. Cover the card with powdered talcum and leave exposed to the air until all the petroleum is evaporated. The cards will look like new.—*Neueste Erfind. u. Erfahr.*

Gold Luster on Leather.—Mix 3¾ pounds gamboge with 30 grammes (1½ ounces) oil turpentine; in another vessel bring together 5½ pounds seedlac, 5½ pounds sandarac and 150 grammes (8 ounces) Venetian turpentine. Mix all together and heat on waterbath. Color with wood dyes and apply to leather; the yellow dye will give a beautiful gold luster. Aniline dyes must *not* be used.—*Ledertechn. Rundschau.*

A Vanishing Photograph.—To make a photograph disappear use a "goldbath" to which has been added 2 grammes of uranium nitrate. The picture will gradually turn pale and soon disappear altogether. Formula for "goldbath": Distilled water, 1,000 cubic centimeters; hypo, 250 grammes; ammonium sulphocyanide, 25 grammes; salommonia, 40 grammes; lead nitrate, 20 grammes; citric acid, 6 grammes, and solution of gold chloride (1 per cent), 60 cubic centimeters.—*Neueste Erfind. u. Erfahr.*

Luminous Colors on Clothing.—Commercial paints and ordinary varnish affect the luminous properties of calcium sulphide. A mass which does not affect the phosphorescence may be obtained in the following manner: Take one pound of borax and two pounds of bleached shellac and boil together with one gallon of water. Add sufficient phosphorescent calcium sulphide and apply to the cloth. Dresses prepared with this mass have been used for stage effects. The paint will not come off and if ordinary care is taken can be used for years.

Acidproofing of Corks.—Make a solution of 500 parts of gelatine in 24 parts of glycerine, heating to 45 deg. Cent. Immerse the corks in this liquid and let stand for some time; then take out, wash thoroughly with water and let dry. Mix 20 parts of vaseline and 70 parts of paraffine, heating to 40 deg. Cent., and treat the corks with this mixture. Take out and allow to dry. They are not affected by acids and alkalies and other liquids, provided the last are not solvents for vaseline and paraffine (such as ether, benzine, benzol).—*Wiener Drogisten-Zeitung.*

"Electric" Sparklers.—Electric sparklers were imported from Europe a few years ago and were used on the stage of the Hippodrome in one of their productions. They have been found to contain the following ingredients: Barium nitrate, 50 per cent; iron filings, 30 per cent; powdered aluminium, 8 per cent, and dextrin, 12 per cent. To get the largest amount of sparks with very little or no flame it is necessary that the chemicals be mixed thoroughly and that they be in a finely powdered state. Lumps of dextrin will cause the formation of little flames which will spoil the effect. The amount of dextrin seems to be rather high. I obtained the best result by using the proportions as follows: Barium nitrate, 18 parts (by weight); iron filings, 20 parts; powdered aluminium, 2 parts; dextrin, 1½ parts. This mixture is made into a thick paste with water, applied to thick wires or rods and allowed to dry.—A. S. Neumark.

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